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COMPLETE SPECIFICATION

Improvements in Surgical Operating Table

We, AIR REDUCTION COMPANY, INCORPORATED, a Corporation organised and existing under the Laws of the State of New York, United States of America, of 60, East 42nd Street, New York 17, State of New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to surgical operating tables.

Due to the highly specialised nature of present surgical practices, the operating table has become increasingly important as a tool of the surgeon, who relies upon the complex adjustments of the table to position the patient in a manner providing the most desirable access to the field of the operation. It is frequently necessary, in the course of an operation, to rearrange the table structure in order to alter the position of the patient. Present surgical techniques require operating tables that are capable of extensive and varied adjustments and which are equipped with readily-accessible control mechanism for making the necessary adjustments quickly, without delaying the operation. Since the utmost care must be exercised in moving the patient gently, so as to avoid shock, injury, or discomfort, the table mechanism must also be capable of precisely-controllable movements.

In order to provide operating tables particularly adapted to meet the exacting standards of present surgical practices, it has been proposed to utilise motor-driven adjusting mechanisms. For example, one suggestion has been to provide operating tables with electric motor devices operatively associated with the adjustable portions of the table structure. The adjustment of the table would thus be facilitated and controllable from a remote station by selective operation of the separate motor devices. It is objectionable, however, in most cases to use electric devices in operating rooms, where an explosion hazard exists due to the presence of anaesthetic gases. Usually only the most essential electrical equipment is located in the area of operation and then only when stringent specifications are met by the provision of suitable explosion-proof apparatus. While a type of explosion-proof electric motor is available, the motor housing of this motor is not compact and the necessity of providing the necessary number of motors of this type, or even of the ordinary type, for completely controlling all the movements of the table creates a cumbersome and impractical structure.

Some tables have utilised hydraulic means for actuation of the table adjusting mechanism. This type of operating table overcomes the explosion hazard, but there has yet been no hydraulic table which has proved completely acceptable for surgical purposes and commercially satisfactory. One of the difficulties has been that certain mechanical limitations have had to be incorporated in the table construction in order to accommodate the hydraulic or fluid actuating devices. Thus all of the variations of adjustment and the ranges of movement of the table members which are desired could not be obtained. Furthermore, tables designed or intended for complete hydraulic actuation have heretofore had inadequate fluid control circuits and valve means. To compensate for these deficiencies, some hydraulic tables have been only partially mechanised by the hydraulic devices and have had the remaining adjustments made by manual means. In prior hydraulic tables, controlled rates of movement of the table members in both directions of movement has not been accomplished. There has also been the inherent problem of avoiding leakage of oil, or other actuating fluid, from the control circuit.

It is an object of this invention to provide an improved hydraulic operating table which overcomes the inherent disadvantages in previous tables of this type.

Another object of the invention is to provide an improved fluid control circuit for operating tables having selective and compound table movements.

Another object is to provide an improved table structure especially adapted to accommodate fluid actuating mechanisms for the entire table without limiting the ranges of adjustment thereof and which affords a strong, rigid support for the patient in all positions.

A further object of the invention is to provide an improved arrangement of valve means and valve adjusting mechanism for controlling the movements of an adjustable surgical table.

A further object of the invention is to provide discharge valve means for regulating, under predetermined conditions, the discharge flow of the actuating fluid in the control circuit of an hydraulic surgical table, to prevent excessive rates of movement of the hydraulic cylinder table actuating means.

A further object is to provide improved speed control means operable in connection with the table control circuit for adjusting the rates of movement of the cylinder devices.

A still further object of the invention is to provide improvements in fluid circuits for series-connected surgical table actuating cylinders.

Other objects and advantages of the invention will be better understood by referring to the following description and accompanying drawings of a preferred embodiment of the invention in which:—

Fig. 1 is a side elevation, partially in section, of an operating table arranged and constructed in accordance with the invention;

Fig. 2 is a top plan view, partially in section, of the table shown in Fig. 1;

Fig. 3 is a vertical sectional elevation taken substantially along line 3—3 in Fig. 1, partially sectioned in the pedestal looking in the direction of the arrows;

Fig. 4 is a sectional elevation taken along line 4—4 in Fig. 2 looking in the direction of the arrows;

Fig. 5 is a sectional elevation taken along line 5—5 in Fig. 2 looking in the direction of the arrows, the table platform sections having been removed therefrom and the reversed Trendelenburg position of the table being shown in dotted lines;

Fig. 6 is a sectional elevation taken substantially along line 6—6 in Fig. 5 looking in the direction of the arrows, including also a side-tilted position of the table frame in dotted lines;

Fig. 7 is a sectional elevation taken along line 7—7 in Fig. 6 looking in the direction of the arrows, showing the table frame and associated cylinder mechanism in the tilted position indicated in dotted lines in Fig. 6;

Fig. 8 is a sectional elevation taken substantially along line 8—8 in Fig. 7 looking in the direction of the arrows, certain parts being omitted to simplify the drawing;

Fig. 9 is a sectional elevation taken substantially along line 9—9 in Fig. 4 looking in the direction of the arrows;

Fig. 10 is a plan view sectioned along the line 10—10 in Fig. 9 looking in the direction of the arrows;

Fig. 11 is a sectional elevation taken along the line 11—11 in Fig. 9 looking in the direction of the arrows, showing the detailed construction of a compound cylinder device mounted in the table frame for supporting portions of the back and seat table sections and the kidney bridge;

Fig. 12 is a sectional plan view taken substantially on line 12—12 in Fig. 1 looking in the direction of the arrows:

Fig. 13 is a sectional elevation taken substantially on line 13—13 in Fig. 12 looking in the direction of the arrows;

Fig. 14 is a front partial view, partly in section, taken substantially along line 14—14 in Fig. 1, illustrating the master control valve mechanism and showing the compactly-arranged valve units;

Fig. 15 is a sectional elevation taken on line 15—15 in Fig. 14;

Fig. 16 is a sectional elevation taken on line 16—16 in Fig. 14, the valve units being omitted;

Fig. 17 is an end view of the dial face at the end of the arm casing in Fig. 14;

Fig. 18 is a sectional plan view of the master control valve assembly including the valve units, taken substantially along the line 18—18 in Fig. 16;

Fig. 19 is an enlarged partial section taken transversely through the valve assembly in Fig. 18 illustrating the structure of the valve units therein;

Fig. 20 is a diagrammatic illustration of the distribution system of the fluid circuit for the operating table including the hydraulic cylinder devices and selector valve housing of the master control valve mechanism;

Fig. 21 is a diagrammatic illustration of the supply system of the fluid circuit for the operating table including the fluid pump and reversing valve housing of the master control valve mechanism;

Fig. 22 is a diagrammatic illustration of an alternative form of the fluid circuit embodying speed control means;

Fig. 23 is a fragmentary sectional view taken substantially along the line 23—23 in Fig. 18 looking in the direction of the arrows;

Fig. 24 is a partial sectional plan view

corresponding to a portion of that shown in Fig. 18 of a modified form of the master valve assembly in Fig. 14, showing the inclusion of a speed control valve unit;

Fig. 25 is an enlarged sectional view taken transversely through the valve units in Fig. 24 showing the cam operating means;

Fig. 26 is a longitudinal sectional view of the variable-pressure relief valve shown schematically in the circuit diagram of Fig. 21;

Fig. 27 is a longitudinal sectional view of the by-pass regulating valve of the speed control mechanism shown schematically in the circuit diagram of Fig. 22;

Figs. 28-31 are schematic illustrations showing the table in some of the various operating positions obtainable by adjustment of the control mechanism which are respectively, Trendelenburg position, centre break or Mayo-kidney position, reflex-abdominal position, and the chair position.

The preferred embodiment of the invention, as shown in the drawings, generally described, comprises an hydraulic operating table (Figs. 1 and 2) having a plurality of adjustable members, hydraulic cylinder devices operatively associated with each of the adjustable members, and a fluid system including master control valve means for selectively administering fluid to the cylinder devices. The table structure includes a base, a platform structure, and a pedestal adapted to raise or lower the platform. The table platform structure comprises a platform consisting of a plurality of table sections and a rigid supporting frame in which the table sections are adjustably mounted, each table section having a fluid-actuated motor device for adjusting the table sections relative to each other and with respect to the table frame. Preferably, the frame carries the back, seat, and leg sections and a kidney bridge which is movable vertically with respect to the mounting frame.

Universal means are provided (Figs. 4-8) for mounting the table frame on the pedestal whereby the table platform may be tilted as a unit laterally and longitudinally, such adjusting means having an extensive angular range of displacement and being so constructed as to afford exceptional structural rigidity throughout its entire range of motion. The universal means comprises a bracket pivotally mounted on the table pedestal in which first and second double-acting fluid cylinder devices are mounted in relative transverse planes.

The system for administering fluid to the cylinder devices (Figs. 20 and 21) is an improved fluid circuit which includes a reservoir, a pump for supplying fluid under relatively high pressure to the circuit from the reservoir, low pressure conduit means for returning fluid to said reservoir, selector valve units for selectively completing operating circuits through the respective hydraulic cylinders, and reversing valve means having reversible high and low fluid pressure connections with the selector units to produce a reversible flow of actuating fluid in said operating circuits. The reversing valve means thereby controls the direction of movement of the associated table members. The circuit also contains a variable pressure-relief valve for limiting the rate of discharge from the circuit when the cylinder devices are moved in the direction of the force which is exerted by the load supported thereon. A modification of the control circuit (Fig. 22) includes an adjustable speed control valve and a circuit by-pass conduit wherein speed adjustments are made through manipulation of the control valve. The speeds of operation are maintained independent of the load carried by the table through the effect of a regulating valve in the by-pass conduit. In addition, over-travel means are incorporated in some of the cylinder devices to permit flushing of the circuit and co-ordination between cylinder devices that are series-connected for simultaneous operation.

The selector valve units are mounted in a common selector valve body (Figs. 14 and 18). Each of the valve units is operated to open a circuit to a corresponding cylinder mechanism or mechanisms by valve actuation means mounted in the selector valve body. Adjusting means therefor extend outwardly to a point within easy reach of the operator at all times and there is provided indexing means associated therewith, whereby the fluid circuit actuated in each of the respective positions of the selector adjusting means is indicated. The reversing valve means are preferably mounted on the same housing as the selector valve means forming a master valve assembly housing. The adjusting means for the reversing valve extend substantially co-extensively with the adjusting means for said selector valve so that both of these valve means may be operated from a single position.

Referring now in detail to the specific construction shown in the drawings, an operating table constructed and arranged in accordance with the preferred form of the invention is shown in Fig. 1, there being omitted, however, from this and the other figures illustrating the table structure, the several fluid conduits making up the fluid control circuit which connects the several fluid-actuated elements and valves of the table circuit. Confusion of the structural drawings due to such detail is thereby avoided, while the necessary fluid circuit connections may be clearly understood by reference to the circuit diagram of Figs. 20 and 21, taken in connection with the description hereinafter.

The operating table is supported by a base

10 having four corner stanchions 11. Each of the stanchions contains a caster wheel 12 which is extendable by means of an hydraulic caster cylinder device 13. When the pistons in cylinder devices 13 are extended, the table is raised from the stanchion supports and rests on the caster wheels 12, facilitating movement of the table. The hydraulic caster cylinder devices are actuated by means of a foot pump 14, seen in Fig 13, provided with an operating lever 15, the outer end of which is adapted to be depressed to actuate the pump. Fluid from the foot pump is forced into the respective cylinders 13 through series-connected conduits 16, best seen in Fig. 12, into which the cylinders 13 are tapped. To lower the table and permit the base 10 to rest on the stanchion supports 11, a lever 17 is depressed which opens check valve means in the foot pump and permits the fluid to drain from the cylinders 13.

The base 10 comprises a housing 18 having a removable cover 19, Fig. 1, through which access may be had to the table mechanism contained therein. The base 10 houses a container, or reservoir, 20 having a vent 21 holding a supply of hydraulic fluid at atmospheric pressure for the table control circuit, an electric motor 22 and an hydraulic constant-displacement pump 23 coupled to the motor 22. A power line 22′ is connected to a source of electric current to operate motor 22 which is fully explosion proof in the manner acceptable to surgical operating room specifications. Other equipment housed therein will be described in greater detail hereinafter.

The housing 18 has a heavy, rigid base plate 24, Fig 13, from which a central column 25 extends upwardly through the cover 19. As seen in Fig. 1, the column 25 constitutes the lower section of the table pedestal 26 wherein a telescoping inner column 27 is received. The inner column 27 carries grooved guide members 28 at its lower end which ride on vertical longitudinal ribs 29 mounted in the bore of the base column 25 to prevent rotation of the telescoping column therein. Two annular bearing blocks 30, secured in the base column, receive the inner column, taking up the slack between the inner and outer columns and adding greater rigidity to the pedestal support. At the upper end of telescoping member 27 an end plate, or cap, 31 is provided on which the table platform structure designated generally at 32 is mounted through a yoke structure 33.

The table platform structure 32 may be vertically adjusted as a unit by means of the hydraulic cylinder mechanism including an upright shaft or rod 34 and piston 35, which are stanchioned in the base, and a cylinder barrel 36 which is mounted within the pedestal member 27 and depends from the end cap 31. Fluid for controlling the operation of the pedestal cylinder mechanism is admitted to the cylinder barrel above or below the piston depending upon the movement desired, while the fluid on the opposite side of the piston is permitted to exhaust from the barrel. Referring to Fig. 3, a fluid line 37 communicates with the cylinder barrel 36 through a passage 38 in end cap 31 and a connecting tube 39 which opens into the barrel chamber below the piston. A conduit 40 is received by a suitable fluid fitting in end cap 31, wherefrom a passage 41 opens through end plate 31 into the bore of the cylinder barrel above the piston. Elevation of the table is effected by admitting high pressure fluid to the cylinder barrel above the piston through conduit 40 and passage 41 which urges the cylinder barrel upwardly and extends the pedestal. Fluid is simultaneously exhausted from the cylinder barrel through connecting tube 39, passage 38 and conduit 37. The lowering movement is accomplished by reversing the fluid circuit connections and admitting the high pressure fluid to the underside of the piston through conduit 37. Fluid in the cylinder barrel above the piston is exhausted therefrom as the pedestal is retracted. The exhausting of fluid at reduced pressure from the cylinder barrel is regulated to control the rate of displacement of the cylinder mechanism and therefore the movement of the table as will be hereinafter more fully described. The administration of the actuating fluid is controlled by valve control means in the hydraulic circuit as will also be later described.

The table platform structure 32 comprises a plurality of adjustable sections supported in a rigid frame 42, Figs. 1 and 2, including cross-beam members 43 and side members 44. The table sections include a back section 45, an intermediate section 46, a kidney bridge 47, a seat section 48 and a leg section 49. Along both sides of the table platform there are provided slide bars 50 on which slidable mounting fixtures 51 are situated. The mounting fixtures are provided for supporting the various auxiliary equipment used in conjunction with the operating table, such as a canopy frame, arm or leg slings, etc. A head rest 52 is pivotally supported on a cross member 53 having slide boxes 54 thereon that are received on extensions of the slide bars 50. The head rest is angularly adjustable about the cross member 53 and is provided with a ratchet type locking mechanism 55 to secure it in its adjusted positions. The seat section supports at its outer end clamp devices G which accommodate knee crutch supports or other equipment. The clamps G are an improved type of clamp which are particularly adapted for mounting the knee crutch support and are identical to the clamping means described and claimed in

Edward F. Fullwood's United States Patent No. 2,622,831 dated December 23, 1952.

Side plates 56 are fastened by bolts 56' to the side frame members 44. Thus the plates 56 constitute the side walls of a shield partially enclosing the table superstructure in the frame 42.

Back section 45 is hinged at 57, Fig. 4, to the intermediate platform section 46 and is supported on the table frame 42 for pivotal movement by hydraulic cylinder devices 58 and 59. The cylinder devices, both of which are seen in Fig. 2, are rotatably mounted on trunnion axles 60 in bifurcated portions 61 of the table frame. Each of the cylinder devices has a plunger or piston rod 62 which carries a lug 63, Fig. 4, that is hingedly received at 64 in the back section. The plungers are reciprocally movable within cylinder members 65 which are in turn piston-rod elements adapted to be reciprocated in the outer barrel portions 66 and 67 respectively of the cylinder devices 58 and 59. Thus, these cylinder devices (also shown schematically at 58 and 59 in Fig. 20) are of the compound cylinder type having inner and outer cylinders and piston-rod elements co-operating to provide a maximum displacement which is particularly useful for rotating the back section 42 through a wide range of angular adjustments. As will later be seen, the inner and outer cylinder devices may be operated independently or in unison through the table control circuit.

Fluid is delivered to and from the barrel portions 66 and 67 through fluid lines 68 and 69, and lines 70 and 71 respectively, whereby the piston rods 65 are actuated. Fluid for actuation of the inner piston rods 62 is provided by means of fluid conduits 72 and 73 in the cylinder device 58 and fluid conduits 74 and 75 in the cylinder device 59. The fluid fittings receiving the pairs of conduits 72, 73 and 74, 75 are mounted at the lower ends of the inner cylinder barrels 65 instead of opposite ends of the cylinder barrels as in conventional cylinders. In each cylinder the fittings for conduits 72 and 74 open directly into the lower ends of the respective piston chambers. The fittings receiving conduits 72 and 74 connect internally of the cylinder barrels with tubes (not shown) that pass through suitable openings in the piston members into the upper ends of the piston chamber. Thus connections for alternatively delivering fluid at either side of the piston in each of the devices are afforded. The specific construction of the cylinders is unrelated to the present invention and has not therefore been illustrated in detail in the drawings. When the devices 58 and 59 are actuated to raise the back section, high pressure fluid is admitted through the lines 69 and 71 to the outer barrel portions 66 and 67 which causes the cylinder-piston members 65 to be drawn upwardly therein. Ejection of the inner piston rods 62 from the members 65 occurs by administering actuating fluid through the conduits 73 and 75 respectively. In order to lower the back section, the high pressure fluid is admitted to the opposite ends of the cylinders through conduits 68 and 70 in outer barrels 65 and 66 and in lines 72 and 74 in piston-cylinder members 65, respectively. The means by which control fluid is administered to the supply conduits will be hereinafter described.

Seat section 48 is also hinged to intermediate section 46 as shown at 76, Figs. 2 and 4. This section is adjusted by hydraulic cylinders 77 and 78 which are pivoted on trunnions 79 in bifurcations 80 of frame 42. Each cylinder contains a piston rod or plunger 81 having a lug 82 which is received by pin connection 83 in the seat section.

The cylinders 77 and 78 are provided, respectively, with conduits 84 and 85 at the blank ends of the cylinders and conduits 86 and 87 at the rod ends thereof. Fluid is administered to the cylinders through these conduits to raise or lower the seat section about its hinge connection 76. For example, the seat section is elevated by admitting high pressure fluid to the blank ends of the cylinders through fluid conduits 84 and 85 which causes the piston rods 81 to be projected from the cylinders. In order to reverse the movement of the seat section, high pressure fluid is admitted to the rod-end of the cylinders through the fluid conduits 86 and 87 respectively.

Intermediate section 46 is mounted in table frame 42 for vertical movement, which is accomplished by cylinder devices 88 and 89, Fig. 9. Enlarged portions 90 in the frame receive the cylinders wherein the barrels 91 are soldered or otherwise rigidly fixed. Each cylinder has a plunger 92 movable vertically within the cylinder barrels. Brackets 93, extending longitudinally of the table, as shown in Fig. 5 support the section 46 on the plungers 92. The cylinder devices 88 and 89 are provided with fluid conduits 94 and 95 respectively, seen also in Fig. 3, at the upper ends of the cylinder barrels 91 and with conduits 96 and 97, respectively, at the lower ends thereof. Conduits 94 and 95 are received on the usual fluid fittings which are mounted in the enlarged portions 90 of the frame through which passages register with openings in the side walls of the cylinders as illustrated by the opening 94' in hydraulic cylinder 88.

The vertically adjustable intermediate section 46 on which are hinged back section 45 and seat section 48 affords an improved structural arrangement of the table platform. For example, the inner hinge points 57 and 76, seen in Fig. 4, respectively, may be elevated simultaneously, thus producing a

Mayo-Kidney positioning of the table platform in a single movement. In this position of the table the back and seat sections are inclined downwardly on opposite sides of their common hinge points, so that the abdominal region of the patient is elevated. To raise section 46, high pressure fluid is admitted to the lower ends of the cylinders through the conduits 96 and 97 which urges the plungers 92 upwardly in the cylinders. To retract the plungers 92 the actuating fluid is introduced into the upper ends of the cylinder barrels through the fluid lines 94 and 95. The control of the cylinder devices is effected by control mechanism associated with the table hydraulic circuit which will be described hereinafter.

The kidney bridge 47 is supported on stems 98 which project out of the plungers 92 of the cylinder devices 88 and 89 and are received in sockets 99 in the kidney bridge. These stems constitute inner piston rod members which are movable within the plunger members 92, as illustrated schematically in Fig. 20. The detailed construction of each of the hydraulic cylinder devices 88 and 89 which support the section 46 is shown in Fig. 11. The stem 98, it will be seen, comprises a piston rod having a piston 100 which is slidable within the bore of cylindrical piston rod member 92. The piston rod 92 carries a piston 92′ which is received in the chamber 91′ whereby the piston rod may be elevated to raise the intermediate section 46, as before described. The inner piston rod 98 may be operated independently of the piston rod 92 by separately controlling the actuating fluid delivered to the bore of the cylindrical member 92 for actuation of piston 100, and the fluid delivered to chamber 91′ for actuation of piston 92′. Piston 100 is provided with an overtravel valve mechanism comprising ball elements 101 which are disposed in passage 101′, through which fluid is enabled to pass between the blank-end face and the rod-end face of the piston. The ball elements are urged against openings at opposite ends of the passage 101′ by a spring element 101″ interposed between the ball elements. The present construction differs from prior constructions in that the valve is adapted to be operated only at the blank end of the cylinder to permit fluid passage through the piston, instead of both ends of the cylinder. Thus in the cylinders 92 the pistons 100 are provided with overtravel means in the downward movement of the piston. Fluid lines communicating with the blank ends of hollow piston rods 92 in the cylinders 88 and 89 respectively are indicated at 102 and 103, Fig. 9. Rod-end fluid connections for the cylinder devices are shown at 104 and 105.

When it is desired to raise the kidney bridge, high pressure fluid is supplied through conduits 102 and 103 to the blank ends of the piston rod cylinder members 92. This causes the kidney bridge to be elevated, as indicated by the dotted lines in Fig. 11, independently of the section 46 which is immobilised as long as actuating fluid is not administered to the outer cylinder barrels 91. To lower kidney bridge 47, the high pressure fluid is admitted to the cylinders 92 through the rod-end conduits 104 and 105. When the cylinder members 92 are actuated, as before described, the inner piston rods 98 and the kidney bridge are carried in the same relative position therewith. The kidney bridge is controlled by means of control mechanism associated with the hydraulic table circuit, as will be described hereinafter.

The leg section 49 is hinged by means of hinge connections 106 to the outer end of the seat section, as best seen in Figs. 1 and 2. The leg section is adjusted angularly about the hinge connections by a pair of hydraulic cylinders 107 pivoted on brackets 108 on the seat section and on lugs 108′ on the outer end of the leg section. The cylinders 107 have cylinder barrels 107′ and piston rods 107″ which form an expansible linkage adapted to rotate the hinged leg section 49. Conduits 109 are provided at the blank-ends of the cylinders 107 and conduits 110 are provided at the rod-ends thereof.

High pressure fluid is admitted to the rod-ends of cylinders 107 through the conduits 110 in order to lower the leg section. By reversing the circuit connections, the high pressure fluid is delivered to the blank-ends of the cylinders through the conduits 109 to raise the leg section. The delivery of the actuation fluid and control of the leg section cylinders is accomplished by control mechanism associated with the hydraulic circuit for the table and provided with overtravel means, as will be described hereinafter. The functioning of the piston overtravel means in the control circuit will also be later described.

The table platform and frame 42, whereon the platform sections are adjustably supported, are mounted on the table pedestal for universal movement as a unit by means of the yoke structure 33. Referring to Fig. 9, the yoke structure comprises an inverted yoke 111 having depending side members 112 which are pivoted for rotation longitudinally of the table on studs 112′ held in arms 113 extending downwardly from the pedestal cap 31. The yoke 111 is so formed as to include bosses 114, seen also in Fig. 4, which provide bearings in which a cylinder barrel 115 of hydraulic cylinder device 116 is journalled. The ends of the barrel 115 are fixed in flanges 117 formed in the central portions of cross-beams 43, whereby the table frame may be tilted laterally about the longitudinal axis of the cylinder 115

which acts as a hinge pin. Referring now also to Figs. 5, 6, 7, and 8, such lateral tilting movement of the frame is effected by means of an hydraulic cylinder device 118 disposed in a plane substantially transverse to the plane of cylinder device 116 and supported on a fixed plunger, or piston rod, 119 mounted between rearward extensions 120 of yoke side arms 112, mounted centrally on the piston rod 119, and within cylinder barrel 121 is a fixed piston 121'. Barrel 121 of the cylinder device carries lugs 122 (Fig. 8) into which studs 123 are threaded and adjusted to provide a socket for engagement of ball member 124. The ball member comprises an outer universal joint connection for stirrup-shaped link 125 which is hinged at 126 in flange 117 of the rear cross-beam member 43 of the table frame. The stirrup link member is pivotable vertically about the axis of hinge connection 126, but is laterally rigid with respect to the cross-beam member 43. Thus the table frame 42 is tilted by lateral movement of the barrel 121 which pulls the link 125 toward either side of its centre position causing the cross-beam member 43 to be rotated about the axis of the cylinder 116. The displacement of the tilting mechanism in tilting the table frame toward the right, as viewed from the foot end of the table, is illustrated in Figs. 7 and 8 and by the dotted lines in Fig. 6. During such movement it is necessary to accommodate the relative displacement between the hinge connection 126 on cross-beam 43 which moves arcuately, and the socket connection on cylinder barrel 121 which would ordinarily be displaced on a straight line parallel to the axis of the cylinder. In this construction the barrel is permitted to rotate a small amount on the piston rod 119, as indicated by the angular displacement of the cylinder barrel from its normal position, shown in dotted lines in Fig. 7, which together with the pivotal movement of link 125 and the freedom of the ball socket joint provides a flexible driving connection. The cylinder is provided with fluid conduits 127 and 128 communicating with the bore of the cylinder barrel on opposite sides of the piston 121', as seen in Fig. 6. When the table frame is to be tilted in the direction shown by the displaced phantom figure in Fig. 6, the high pressure fluid is administered to the cylinder through conduit 127, whereupon the barrel 121 is urged to the left of this figure. Figs. 7 and 8 illustrate the displaced position of the cylinder device 118. To tilt the table in the opposite direction the high pressure fluid is administered through conduit 128.

The table platform 32 is tilted in the longitudinal plane to provide the Trendelenburg and Reverse-Trendelenburg positions by the hydraulic cylinder device 116, which is otherwise referred to as the Trendelenburg cylinder. The cylinder 116 is provided with a piston rod 129, Fig. 4, having a piston 130 which is received in the bore of the cylinder barrel 115. At its outermost end rod 129 is secured to the central portion of a cross-piece 131, which has its opposite ends fastened to rack bars 132, seen in Figs. 1 and 2. The rack bars 132 extend rearwardly in parallel relation to the piston rod 129 and are slidably received in longitudinal grooves 133 in yoke member 111, as seen in Fig. 3. The undersides of rack bars 132 are provided with teeth 134, Fig. 5, which mesh with teeth 135 formed on circular gear segments 136. The gear segments are mounted on the pedestal cap 31 by bolts 137 shown passing upwardly through the cap 31 into the lower portions of the gear segments in Figs. 4, 9, and 10. Piston 130 is thus connected with cap 31 through piston rod 129, cross-piece 131, rack bars 132 and gear segments 136; whereas the cylinder barrel 115 is fixed against axial movement in the yoke 111 by collars 117 secured to opposite ends of the barrel. Thus when fluid is admitted under pressure to the cylinder 116 to cause relative displacement between the piston and cylinder barrel the yoke is moved relative to the cap and pedestal, and this motion will be an angular motion about the axis of the yoke pivots 112'. Gear segments 136 are so located that their pitch circles are in concentric relation to the circular path generated by the angular movement of the yoke 111. Thus, the rack bars 132, which are supported from the yoke by piston rod 123 and yoke grooves 133, remain tangent to the gear segments as the yoke pivots about axis 112', and the rack teeth 134 are maintained in engagement with the gear teeth 135 in all angular positions of the yoke. As the yoke 111 and frame assembly 42 mounted thereon are rotated, the rack bars rotate with the yoke and frame and move about the gear segments 136 in the manner of rocker elements; successive teeth thereon engaging with the corresponding gear teeth of the gear segments, thus maintaining a positive engagement in all positions. During such rotational movement the yoke 111 slides relative to the rack in the grooves 133. A displaced position of the table frame 42 is shown in Fig. 5, corresponding to a Reverse-Trendelenburg position wherein the head end of the table is elevated.

The Trendelenburg cylinder is provided with a fluid conduit 138 at the blank end and with a conduit 139 at the rod end. Fluid introduced through conduit 138 expands the chamber volume between the piston and the blank end of the cylinder causing the yoke 111 and frame 42 to be moved toward the right in this figure about the pivots 112' as indicated by the dotted lines in Fig. 5. To

reverse the movement of the table or to move the table platform to a Trendelenburg position, the high pressure fluid is admitted to cylinder 115 through the rod-end conduit 139. This urges the cylinder barrel 115 further toward the left in Fig. 5, producing a turning movement of the yoke and table frame in the same direction.

The particular construction described for the Trendelenburg movement has the notable advantage of providing a positive engagement through the rack bars and gear segments in all angular positions, and providing important structural rigidity even at extreme Trendelenburg positions. Moreover, this construction permits the entire table platform to be angularly adjusted in the longitudinal plane as a unit, without necessitating any alternation of a previous relative disposition of the table platform sections. Similarly, the construction affords desirable rigidity for lateral tilting of the table platform.

The control valve mechanism for controlling the circulation of actuating fluid in the table circuit to the hydraulic cylinder devices comprises a master valve unit 140, Fig. 2, which is mounted in the frame 42 on arm extensions 141 of the side frame members 44. Fluid lines connect the master valve unit with the several cylinder devices, as will be described hereinafter. The master valve unit 140 has operating means comprising a shaft 142 which extends outwardly toward one side of the table. The shaft 142 is received in a housing having an angle extension 143 mounted on the side plate 56 attached to frame 42 and extending upwardly and toward the head end of the table in which the controls for the valve operating means are located. The arm extension 143 terminates in a truncated dial face 144 which is at an oblique angle designed for easy vision of the dial markings by the operator. A pointer 145 is correlated with the respective positions of the valve operating means which are indicated on the dial face.

Referring to Fig. 14, the master valve unit and valve operating mechanism, described and claimed *per se* in our British Application No. 882/53 filed 12th January, 1953 (Serial No. 728,094) are shown in greater detail. The valve unit 140 is a composite structure made up of a selector valve assembly 146 and a reversing valve assembly 147. The shaft assembly 142 comprises an inner shaft 148 and an outer shaft 149 wherein the inner shaft is co-axially and rotatably disposed; the co-axial shafts being adapted to be operated independently of one another. The shaft 149 is journalled in the selector valve 146 and in an extension bearing 149′ which projects from side plate 56 of the table frame and supports the shaft assembly at its outer extremity. The shaft 149 carries on its outer end a sprocket 150 which is connected by a drive chain 151 with a second sprocket 152 keyed in a shaft 153 having a hand-adjusting knob 154. Manipulation of knob 154 rotates the shaft 149 through the chain and sprocket drive whereby the selector valve mechanism is actuated, as will be described. A pair of bevel gears 155 and 156 are arranged to transmit the adjustments of the drive shaft 153 to pointer indicator 145 whereby the corresponding positions of the valve-adjusting shaft 149 will be designated on dial face 144.

Operating shaft 148 extends through selector valve housing 146 within the tubular shaft 149 and into the reversing valve housing 147. At its opposite end the inner shaft extends beyond the shaft 149 whereon is held a sprocket 157. This sprocket is linked by a chain 158 to an upper sprocket 159 which is situated on a bushing 160 adapted to revolve independently of the shaft 153 on which it is supported. A lever 161, only a small portion of which is seen in this figure, projects from the bushing member outwardly through the underside of the casing as seen in Fig. 1. The lever is adapted to be pivoted upwardly or downwardly from its normal position shown in this figure, as indicated by the dotted line positions at 161′. Such movement of the lever 161 causes rotation of the shaft 148 which actuates the reversing valve mechanism, as will be described.

The selector valve housing 146 consists of a composite structure including end plate portions 162 and 162′ and a central valve block member 163. The end plates are held against the valve block by bolts, only the ends 163′ of which are visible in the drawings. Banks of valves A, B, and C are arranged circumferentially in the valve block 163 in which each valve is an independent valve unit, substantially as shown in Figs. 18 and 19. Each valve, such as the valve B′ which is enlarged and sectioned in Fig. 19, is a removable unit and is of an improved construction particularly adapted for reversible fluid flow. Each of the valves is provided with a valve seat 164, a valve stem 165 and fluid ports 166 and 167 between which the passage of fluid is controlled by the co-operation of the valve seat and the valve stem. Each of the valves is normally closed, except when the end 172 of the valve stem 165 which protrudes into a central core chamber 173 of the valve housing is depressed by the selector valve actuating mechanism, which includes a roller cam element at 174. Referring to Fig. 18, cam element 174 comprises an elongated pin which is mounted at its opposite ends in disc plates 175 which are carried on the tubular adjusting shaft 149. The pin is disposed

longitudinally within the chamber 173 and at a radius which enables it to come into contact with the protruding valve elements as it is revolved therein around the axis of adjusting shaft 149.

The fluid ports 167 of the bank of valves B communicate with a common manifold chamber 168 which is formed by an annular recess in the face of end plate 162, and similarly fluid ports 167′ of the bank of valves A communicate with a common manifold chamber 169 in the opposite end plate 162′. Manifold chamber 168 is provided with a fluid fitting 170 to which fluid conduit members are attached, and chamber 169 is provided with a similar fluid fitting 171.

In the operation of the selector valve mechanism one of the manifold chambers is supplied with high pressure fluid and the other is connected with the low pressure discharge line. The high pressure fluid is supplied from the high pressure manifold chamber through one of the valves communicating therewith and through fluid circuit conduits to the cylinder devices connected to such valve. Fluid discharged from the energised cylinder device is returned through fluid lines to the corresponding valve unit in communication with the low pressure manifold, thus completing the fluid actuating circuit. The two corresponding valves in each of the valve banks are actuated in unison by the cam element 174, such as in Fig. 18, wherein the valve actuating elements of valves A′ and B′ are simultaneously engaged by the cam element. As the shaft 149 is rotated through its operative positions in the manner hereinbefore described, the cam element comes into engagement with the valve elements of successive corresponding valve units in each of the banks A and B opening the fluid circuit associated with each set of valves. Intermediate valve bank C comprises a series of circumferentially-located valve units which are actuated simultaneously with corresponding valves in banks A and B to complete fluid circuits including the valves C in addition to the corresponding units in banks A and B wherein compound movement of the table is effected, as will be described hereinafter. The conduits received on the fluid fittings 170 and 171 are connected with the reversing valve 147 whereby the high and low pressure lines may be alternatively connected with either of the manifold chambers 168 and 169 to control the direction of fluid movement in the circuits and therefor the direction of movement of the cylinder devices.

Each of the operative positions of the shaft 149 is indicated by the pointer 145 which registers with the corresponding marking on the dial face 144. The markings on the dial face are identified in Fig. 17 by references from *a* to *j* which designate the table movement performed by the hydraulic circuit for that setting. The respective movements corresponding to each of the references are as follows;

(*a*) Table height; (*b*) Leg section; (*c*) Kidney bridge; (*d*) Centre break; (*e*) Reflex abdominal; (*f*) Side tilt; (*g*) Trendelenburg; (*h*) Trendelenburg with leg; (*i*) Chair position; (*j*) Chair without leg. The major positions of the table are shown in Figs. 28 through 31 wherein Fig. 28 illustrates a Trendelenburg position; Fig. 29 illustrates a Centre-break position; Fig. 30 illustrates a Reflex abdominal position; and Fig. 31 illustrates a Chair position.

The shaft 149 and cam adjusting mechanism for the selector valve are centred in the respective operating positions by a detent mechanism 176 which is shown in the Fig. 16 and also in Figs. 14 and 18. In this mechanism a collar 177 is fixed on the shaft 149 on which is secured a sprocket plate 178. The sprocket plate is irregular in contour having a series of depressions, or notches, 179, numbering ten in all, that correspond to each of the operative positions of the adjusting shaft 149. Pins 180 comprising roller elements are provided to engage the sprocket plate at diametrically opposite points. These pins are carried in link members 181, each of which is pivoted at one end on posts 182 set in the selector valve housing and having free outer ends. Springs 183 are hooked on pins 184 on the free ends of link members 181 and are anchored on one of the adjacent fixed posts 182. As seen in Figs. 14 and 18, the link members 181 comprise spaced parallel plates between which the pins 180 are mounted. Thus the pins 180 are resiliently biased toward the sprocket plate in such a manner as to engage in the depressions 179 which are oriented with respect to the operative positions of the shaft 149 and therefor centre the shaft and cam actuating mechanism in each position. At the same time the links are adapted to expand when sufficient torque is applied to the selector valve adjusting shaft, as indicated by the dotted line positions, so that the pins may ride over the sprocket plate between the successive depressions. As a result of this construction, substantially no resultant lateral forces are exerted on the adjusting shaft 149 by the detent mechanism. Thus frictional bearing forces are reduced to a minimum and the adjustment of the valve mechanism is facilitated.

The reversing value 147 embodies a pair of valves L arranged circumferentially in one plane and pairs of valves R and R′ which are arranged in separate circumferential banks. Each of these valve units is substantially identical to the valve units inserted in the cylinder valve housing 146. As shown in Fig. 18, the valve element in each of the

valve units protrudes into a central cylindrical bore 185 wherein the end of shaft 148, having a bushing 186 thereon, is received. The bushing 186 is provided with flat depressions 187 and 188, each of which has a diametrically opposite counterpart not visible in Fig. 18, and a flat 189. The oppositely disposed flats 187 are shown in the sectional view of Fig. 23. In the normal position of the shaft 148 the depressions 187 and 188 register with the protruding ends of the corresponding valve actuating elements which are accommodated therein, allowing all of the valves to remain closed. When the shaft 148 is rotated in the cylindrical bore, the engaging portions of the bushing 186 depress the valve actuating elements and open the valves. The elements in valve units R are disposed off-centre with respect to the notched face 187 (as illustrated in Fig. 23, and as more fully disclosed in our British Application No. 882/53) (Serial No. 728,094), both of these elements protruding through the upper wall of the cylindrical chamber 185. The valve elements of the valves R′ are similarly disposed with respect to the flat faces 186. In this manner when the shaft 148 is rotated in a clock-wise direction, one each of the valves R and R′ are opened while the other valves in each pair remain closed, and when the shaft is rotated in a counter clock-wise direction, the other valves are opened. In addition, the flat 189 by design constitutes a smaller peripheral depression than the flattened portions 187 and 188, and the valve element of the valve L is centrally positioned with respect thereto. As a result the valve L is actuated during the initial rotation of shaft 148 in either direction prior to the actuation of the valves R and R′.

The shaft 148 is biased toward its neutral position (all valves closed) by a centring mechanism 190. This mechanism includes a collar 191 mounted on the protruding end of shaft 148 and having a radial flange 192. A lug 193 projects inwardly from the flange and is adapted to be received in the split end of pin 194, set into the housing 147. A coil spring 195 is carried loosely on the collar 191, Fig. 15, and is provided with sharply-bent ends 196 which are crossed and sprung so as to pinch inwardly around the pin 194. Thus the spring ends 196 urge the lug 193 and pin 194 into mutually intersecting positions, such as shown in Fig. 15, which correspond to the neutral position of the shaft 148.

In the operation of the reversing valve, the high and low pressure fluid lines of the table circuit deliver fluid thereto through conduits hereinafter described in connection with the circuit diagram of Fig. 20. When the shaft 148 is rotated by manipulation of lever 161, seen in Fig. 1, valve L is opened to admit fluid to the reversing valve units R and R′. The effect of rotating the shaft 148 in either a clock-wise or a counter clock-wise direction from the neutral or closed position is to complete the fluid connections between the high and low pressure conduits and the manifold chambers of the selector valve in either of two reverse directions, thus determining the direction in which the actuating fluid is supplied to the manifolding chambers in the cylinder valve housing. When the shaft 148 is in its neutral position the line valve L is closed, no fluid is circulated in the control circuit, and the table mechanism is immobile.

It will be seen that by selective adjustment of the hand knob 154 the desired operation of the operating table mechanism may be selected and then by adjustment of lever 161 the actuating fluid may be circulated through the system to cause such operation in the desired direction.

The table control circuit comprises two distinct portions or systems; the distribution system (Fig. 20) which includes the selector valve assembly, the several fluid cylinder devices, and fluid lines connecting with each cylinder device, and the supply system (Fig. 21) which includes the reversing valve assembly, the reservoir, pump, pressure responsive switch, pressure limiting means, and the several fluid fittings and conduits. The elements of the control circuit are so arranged that only two connecting conduits are necessary to link the portion of the circuit in the table base with the portion of the circuit in the pedestal-mounted frame structure. Thus, the high and low pressure sides of the fluid pump are connected with conduits which extend through the table pedestal, and in turn connect with the master valve unit. The two conduits passing through the pedestal comprise the two telescoping tubular conduits 200 and 201, seen in Figs. 3, 12, and 13. Conduit 200 corresponds to the high pressure fluid for delivering fluid to the reversing valve assembly in the master valve assembly, and conduit 201 corresponds to the low pressure fluid which returns fluid from the reversing valve assembly to the storage reservoir. The conduits have fluid-tight slide fittings 202, Fig. 13, which permit the lengths of the conduits to be varied in accordance with the adjusted height of the operating table.

The table base 10 houses several of the elements of the supply portion of the circuit. Referring first to the sectional views of the table base in Figs. 12 and 13, the arrangement of this portion of the circuit may be seen. The pump 23, mounted on the motor 22 at one side of the reservoir container 20, is connected by a conduit 203 to the reservoir through a T-fitting 203′. A series of connected lengths of tubing 204, which also include a pair of check valves 205 and 206

extend from the outlet of the pump to the lower end of the telescoping conduit 200, within the table pedestal, through which high pressure fluid is administered to the reversing valves and thence to the distributing portion of the hydraulic circuit. The low pressure telescoping conduit 201, through which low pressure fluid is returned from the distributing portion of the circuit, connects at its lower end with tubing 207 which enters through the side of the reservoir container at 208.

The electric motor 22 is connected to a source of power by power cord 22′ which attaches to the motor through a pressure-responsive switch 209. The switch is provided with a tap line 210 which is received in a T-fitting 210′ in the high pressure line 204 whereby the switch is closed and opened in response to variations in the fluid delivery line pressure below and above selected pressure limits. As will later be illustrated, the line pressure is affected by manipulation of the master valve mechanism when it is adjusted for operation of the table mechanism which automatically results in actuation of pressure switch 209 which controls the motor 22. Fluid is thus automatically pumped through the table control circuit when the master valve controls are adjusted and opened for table operation, without requiring other control adjustment for the motor. Similarly, when the circuit connections are closed, increase in fluid pressure in the delivery line above a selected upper limit causes the switch to open the electric circuit to the motor and stop the pump. The switch 209 also prevents overloading of the fluid circuit by excessive pressure.

An accumulator device 211 is connected with the high pressure line 204 through a branch tube 211′. This device is a standard apparatus which is adapted to maintain the desired line pressure when the pump is not in operation by compensating for leakages which may occur in the circuit. The device is conventionally provided with a spring-loaded plunger acting on a small volume of fluid contained therein which is connected through the tube 211′ and a one-way restrictor valve 211″ with the high pressure supply line. Thus, should fluid leakages occur in the circuit, the loss in volume is accommodated by retraction of the plunger which is compressed by spring loading to maintain the fluid in the circuit at the necessary pressure. This device thereby prevents the motor 22 from cycling when the circuit is not in operation. When the reserve volume of fluid in the accumulator is depleted, as by more than ordinary leakage, or when the table has not been operated for a long period, pressure switch 209 closes, causing momentary operation of the pump 23 which restores the required line pressure and recharges the accumulator. The valve 211″ prevents sudden introduction of fluid at a high rate of flow into the control circuit which would produce a surge, or lurch, in the table operation.

An alternate source of high pressure fluid for the control circuit is provided for emergency use, such as in the event of a power failure. Such alternate source comprises the foot pump 14 which is provided with an inlet tubing 212 connecting with the reservoir fitting 203′ and an outlet tube 212′ which is connected with a two-way valve device 213. In the normal position of the valve, as indicated by the handle 213′, fluid pumped through the foot pump is administered to the caster cylinders 13, as before described. When the valve handle is in its second operating position, fluid is delivered from the valve through a conduit 214 which is received on the cross fitting 204′ in the high pressure supply line 204. Thus, in an emergency the foot pump may take the place of the motor-driven pump 23 in supplying high pressure fluid to the control circuit for actuation of the table.

The control circuit for the table is preferably adapted to utilise a non-compressible, or hydraulic, actuating fluid; such, for example, as a conventional hydraulic cylinder oil. In the circuit the various hoses, tubes, and fittings are provided in accordance with standard practices and constitute standard parts commonly used for such purposes. Elements of the control circuit are shown schematically in the circuit diagram. The accumulator, pressure switch and fixed displacement pump are denoted by the letters ACC, PRSW, and PF respectively and several reference numerals applied to parts of the table hereinbefore are applied to the same elements schematically shown in the circuit diagrams.

In order to clarify the control circuit diagram as much as possible, it has been divided into two separate but related figures. Fig. 20 illustrates the distributing portion of the circuit and Fig. 21 illustrates the supply portion of the circuit, these portions of the circuit being connected through the manifold chamber conduits at the right side of Fig. 20 and left side of Fig. 21. In the supply part of the circuit in Fig. 21 it will be seen that fluid is delivered from the reservoir through the pump inlet line 203, pump 23, and the high pressure line 204 to a conduit 200′ which is connected to the line valve L of the reversing valve housing 140. The line 200′ in the circuit diagram schematically represents all of the series-connected conduits extending from the pump outlet conduit 204 in the table base, Fig. 12, and connecting with line valve unit L of the master valve, including the telescoping conduit 200 which extends

through the pedestal.

The alternative system for supplying high pressure fluid in the control circuit is seen to include the fluid line 212 which supplies fluid from the reservoir to the foot pump 14, pump outlet line 212′, and connecting line 214 which delivers the high pressure fluid from the two-way valve 213 to the line 204 at junction 204′. When the two-way valve 213 is set for delivering fluid from the foot pump to the caster cylinders, as illustrated by the position of the valve-adjusting handle 213′ in the circuit diagram, the line 214 is closed. The fluid introduced into the caster cylinders may be bled back into the reservoir by operating the valve handle 17 which manually opens the check valve units 17′ in the foot pump.

The emergency supply line 214 is tapped into the high presure line between the check valves 205 and 206. Valve 205 thus prevents reverse flow of the fluid delivered by the foot pump 14 into pump 23 when the emergency supply source is used. The emergency supply line 214 is provided with a venting valve 214′ through which fluid pressure may be relieved in the system in the event that the foot pump is inadvertently operated beyond the prescribed pressure capacity of the circuit. This valve also functions when the motor pump 23 is in operation as a safety device in the event that the pressure switch 209 fails to shut off the motor 22 at the prescribed line pressure. Fluid vented through the valve is returned to conduit 207 and thence to the reservoir.

When the fluid admitted to the selector valve has been circulated in the distribution portion of the control circuit, hereinafter described in connection with Fig. 20, and is returned to the reversing valve assembly, it is delivered into a common conduit shown at 201′ connecting with the reversing valve, in the circuit diagram of Fig. 21. In the diagram this conduit line schematically represents the series-connected fluid conduits connecting the reversing valve with the return discharge line 207 and the fluid reservoir in the table base, Fig. 12, including the return telescoping conduit 201 which extends through the table pedestal. A variable pressure relief valve 215 is placed in the discharge line 201′ through which the low pressure fluid is discharged. The valve 215 is triggered by the high pressure fluid through a tap line 215′ connecting with the high pressure fluid in conduit 216 whereby the low pressure fluid discharge is regulated to prevent excessive cylinder displacement speeds. The valve is preferably mounted in the table frame so that the tap line 215′ may connect with the high pressure line at the master valve unit, also mounted in the frame, thus eliminating any necessity of an additional expandable conduit passing through the pedestal from the table base. In the circuit the discharge of the hydraulic fluid from the cylinder devices is, under certain conditions, restricted by the variable pressure relief valve to prevent the cylinders from moving at excessive rates of speed. Inasmuch as double-acting cylinders are employed in the circuit and the loads applied thereto are reversible on some of the cylinders, the relief valve means is provided to limit the rate of discharge of oil from the cylinders when the cylinders are moved in the direction of the load. An example is in the operation of the pedestal cylinder wherein it will be seen that hydraulic fluid in raising the table and supporting the load thereon is pumped into the cylinder above the piston while the fluid below the piston may be discharged at atmospheric pressure without difficulty. In the reverse condition when it is desired to pump fluid into the lower portion of the cylinder to lower the table, the discharge of oil above the piston must be restricted to provide a gradual, uniform descent of the table and avoid pulling a vacuum in the chamber below the piston. Unless this is done fluid is ejected from the cylinder at a faster rate than can be supplied by the constant displacement pump. Such restriction of the discharge fluid is accomplished in the pedestal cylinder, and in the case of each cylinder device by the spring loaded variable pressure relief valve 215 in which the pressure tap 215′ causes the relief valve to be controlled by the pressure of the fluid applied to the cylinders. Thus in the case of lifting a load this fluid pressure is sufficient to open the relief valve completely against the marginal spring seating force to reduce the restriction of the discharge fluid without imposing unnecessary load on the pump motor. In the reverse condition (when the cylinder is moving in the direction of the load force) the pressure applied to the relief valve is small, enabling the spring force to close the valve and thus throttle or restrict the discharge flow of cylinder fluid and prevent excessive cylinder-piston displacement speeds.

The variable pressure relief valve is shown in Fig. 26 of the drawings. Referring to this figure it will be seen that the valve 215 comprises a body 300 having a valve cavity 302, a fluid inlet 304, and a fluid outlet 306. The inlet registers with an annular chamber 308 from which radial passages 310 communicate with the valve cavity. A ball valve element 312 having a pin 314 extending therethrough is contained in the valve cavity and is adapted to co-operate with an annular valve seat 316. A spring 318 is compressed in a back cap 320 to urge the ball valve element into seated position; this spring acting against the pressure of the inlet fluid on the ball element. In the inlet portion of the

valve cavity the pin 314 extends through a stem packing 322 into a pressure chamber 324. A plunger 326 is disposed in the pressure chamber into which high pressure fluid from the conduit 200′ is administered through the tap line 215′ which communicates through a passage 328 at the outer end of the chamber 324. A spring 330, retained by an end plug 332, is compressed against the outer end of the plunger 326. In the valve the springs 318 and 330 are arranged to afford a marginal spring seating force acting in the direction to seat the ball valve element 312. The pressure of the fluid through tap line 215′ acting on the plunger 326 augments the force produced by the pressure of the discharge fluid acting against the ball valve element through the inlet 304 to unseat the ball element and permit the return of fluid through the outlet 306 and conduit 201′ to the reservoir. Fluid in the chamber 324 which leaks past the plunger 326 is vented into the discharge 306 of the valve through the small diameter passage 334. In the circuit the marginal spring force acting on the ball valve element of the valve 215 is such as to produce a seating pressure sufficient to retain the fluid under maximum table loading conditions. Thus it will be seen that for any load up to the maximum load, fluid pressure must be provided by the pump in the chamber 324 to augment the pressure in the return conduit 201′ in order to open the valve and permit discharge of the fluid therethrough. Therefore, a positive pump pressure is insured in the circuit under all load conditions and regardless of the direction which the load acts on the cylinders. As a result, fluid may not be discharged into the reservoir at a rate greater than the supply rate of the constant displacement pump and the movement of the cylinder devices will be restricted to the rate predetermined by the output of the pump.

Referring again to the circuit diagram of Fig. 21, in the reversing valve structure the high pressure delivery line 200′ is connected through the valve unit L to conduit 216 on the outlet of the valve unit and thence through branch conduits 217 and 218, with the valves R_1 and R_2' respectively. The valve units R_1 and R_2, comprising the valve bank R, have valve ports communicating with a common conduit 219, and valves R_1' and R_2' of valve bank R′ have a common line conduit 220. As seen in Fig. 20, the conduit 219 terminates in the manifold chamber 168 and the conduit 220 communicates with the manifold chamber 169 of the selector valve. The outlet ports of the valve units R_2 and R_1' are common to the discharge return line 201′ in which fluid displaced from the circuit by circulation is returned to the reservoir 20 through the variable pressure relief valve 215 and conduit 207.

In the operation of the reversing valve as before described, the valve units are actuated by rotation of the cam bushing 186 and the shaft 148, indicated schematically in the circuit drawing. Initial rotation of the shaft in either direction opens the line valve L which allows high pressure fluid to be impressed on both valves R_1 and R_2'. As viewed in the diagram, valve units R_1 and R_1' are adapted to be opened by counterclockwise movement of the cam indicated at 186 whereupon the conduit 219 and manifold chamber 168 of the selector valve are provided with high pressure fluid through the valve R_1, and the conduit 220 and manifold chamber 169 are connected with the low pressure line 201′ through valve R_1'. Conversely, by clockwise rotation of the operating shaft, the valves R_2 and R_2' are opened causing the manifold chamber 169 of the selector valve to receive high pressure fluid and the manifold chamber 168 to be placed in communication with the low pressure return conduit. It will thus be seen that the high pressure and low pressure fluid lines may be alternatively connected with the selector valve manifold chambers 168 and 169 to afford circulation of the actuating fluid in a forward or reverse direction in the control circuit.

The selector valve and hydraulic cylinder circuits are best described by reference to each of the individual circuits completed through the corresponding valve units in each of the selector valve banks, shown in Fig. 20. In the diagram, the valve banks are schematically shown at A, B, and C, respectively. In valve bank A the valve units therein communicate with the manifold chamber 169 through the valve passages 167′, as hereinbefore described. Similarly, the valve units in bank B communicate with the common manifold chamber 168 through the passages 167. Each of the correspondingly labelled valve units which constitute a selector position are adapted to be actuated simultaneously by the operating shaft 149 and cam 174, schematically shown, to complete a corresponding circuit for circulation of the actuating fluid between the manifold chambers. The respective circuits now described are as follows:—

Selector position "a"—Table height.

In selector position "*a*" the valve units so designated in valve banks A and B are opened to complete a circuit for adjusting the table pedestal cylinder 36. In bank A, valve unit "*a*" is connected through a conduit 225 with the tube conduit 40 at the blank end of the pedestal cylinder. At the rod end of the cylinder, the tube conduit 37 connects with a conduit 226 which is received on the valve unit "*a*" in bank B. Thus actuating fluid may be circulated in the completed circuit between the manifold chambers 169 and

168 to lower or raise the table.

Selector position "b"—Leg section.

In selector position "*b*" the valve units are opened to complete a circuit for adjusting the leg section cylinders 107. In bank A, valve unit "b" connects with a conduit 229 which communicates with the conduits 109 at the blank ends of the leg section cylinders. The conduits 110 at the rod ends of the cylinders are connected to conduit 230 which terminates on the valve unit "*b*" in bank B. Thus the control circuit for adjustment of the leg section is completed between the manifold chambers 168 and 169.

Selector position "c"—Kidney bridge.

In selector position "*c*" the valve units are opened to complete a circuit for adjusting the kidney bridge cylinders 92. In bank A, valve unit "*c*" receives conduit 231 which is attached to delivery conduit 103 at the blank end of one of the kidney bridge cylinders 92. At the rod end of the same cylinder, conduit 105 connects with the conduit 102 at the blank end of the other kidney bridge cylinder through an intermediate conduit 232. The rod end of the second cylinder having conduit 104 is connected through a conduit 233 with the valve unit "*c*" in bank B. Thus the supply circuit, through the series-connected kidney bridge cylinders for controlling the kidney bridge, is completed between the selector valve manifold chambers. The overtravel valve mechanisms 100', contained in the piston elements 100 of the cylinders 92, permit the actuating fluid to circulate through the closed circuit, even after the pistons have reached the downward ends of their respective strokes, as hereinbefore described. The inner cylinder 92 of cylinder device 89 is of larger cross-section than the inner cylinder 92 of the cylinder device 88. The proportion of the cylinders is such that the volume displacement at the rod-end of the cylinder 92 in device 89 is made equal to the volume displacement at the blank end of the cylinder 92 in device 88. Thus, upon actuation of the cylinders in the series connected circuit the exchange of fluid between the cylinders causes an equal displacement of both cylinders.

Selector position "d"—Centre break.

The centre break table position is illustrated in Fig. 29.

In selector position "*d*" the valve units are opened to complete a circuit for adjusting the cylinders 91 which are otherwise referred to as the centre-break cylinders. In bank A, valve unit "*d*" is connected with the conduit 97 in the lower portion of one of the cylinders 91 through a conduit 234. The upper end of the same cylinder is connected through conduit 95 and conduits 235 with conduit 96 in the lower end of the other cylinder 91. The upper end of this cylinder 91 is connected through conduit 94 and conduit 236 with the valve unit "*d*" in bank B. Thus, the control circuit for adjusting the intermediate table section 46 is completed through series-connected cylinders 91 between the selector valve manifold chambers.

A pressure relief valve device 237 is connected across one of the cylinders 91 between the fluid conduits 235 and 236. This valve is not shown in detail in the drawings, but is a conventional spring-loaded relief valve mechanism having a uni-directional flow, as indicated by the arrow which enables fluid to by-pass the shunted cylinder 91 when this cylinder has completed its stroke. The relief valve operates only upon completion of the downward movement of the cylinders and causes the by-passed fluid to be delivered to the second cylinder so that both may be displaced to corresponding terminal positions at the ends of their strokes. For example, if fluid leaks from the locked chamber between the pistons of the respective cylinders the piston in the cylinder 91 of cylinder device 88 bottoms first on the downward movement, whereupon additional fluid is supplied to the locked chamber through the valve 237. Thus the valve performs substantially the same function as the overtravel valve mechanism 100' in cylinder devices 92 by providing pressure fluid for the continuation of movement of the piston in cylinder device 89 in the event the piston in cylinder device 88 may bottom first.

It will be seen that if additional fluid is trapped in the locked chamber between the pistons, the piston in cylinder 91 of the cylinder device 89 bottoms first on downward movement. Such fluid is readily bled from the locked chamber by loosening one of the cylinder fittings in the conduit connecting the two cylinder devices.

Selector position "e"—Reflex abdominal.

The reflex abdominal table position is illustrated in Fig. 30.

In selector position "*e*" the valve units "*e*" in each of the valve banks are opened to complete a circuit for adjusting the outer back section cylinders 66 and 67 and the seat section cylinders 77 and 78 simultaneously. In valve bank A valve unit "*e*" is connected with a conduit 238 which communicates with the blank ends of the seat section cylinders 77 and 78 through the conduits 84 and 85 respectively. At the rod ends of the cylinders, tube conduits 86 and 87 join into conduit 239 which is tapped into the conduit 230 at junction 258. The circuit then includes a portion of conduit 230 from which it branches off at junction 240 into an intermediate conduit 241 and thence into a passage 242 common to the valve units "*e*" and "*h*" in valve bank C. The valve unit "*e*" therein receives a conduit 243 which con-

nects at 244 with tube conduits 69 and 71 at the lower ends of the outer back section cylinders 66 and 67, respectively. The upper ends of the cylinders have conduits 68 and 70 which connect with a common conduit 245 that is received on the valve unit "*e*" in valve bank B. Thus, the control circuit for adjusting the back and seat sections angularly about the centre hinge connections to afford a reflex abdominal table movement is completed through the corresponding valve units "*e*" between the selector valve manifold chambers.

A pressure relief valve 237′ is connected across the parallel connected cylinders 66 and 67 between the tube conduit 70 and conduit 243 which is identical to the valve device 237 and functions in the same manner to permit the by-passing of fluid around cylinders 66 and 67.

Selector position "f"—Side tilt.

Side tilting of the table is illustrated in Fig. 6.

In selector position "*f*," the valve units are opened to complete a circuit for adjusting the tilting cylinder 118. In valve bank A, valve unit "*f*" receives a conduit 246 which connects with the conduit 128 at the right-hand end of the cylinder. At the opposite end of the cylinder, conduit 127 connects with conduit 247 which is received on the valve unit "*f*" in valve bank B. Thus, the control circuit for laterally tilting the table platform is completed between the selector valve manifold chambers.

Selector position "g"—Trendelenburg

The Trendelenburg table movement is illustrated in Fig. 28.

In selector position "*g*" the valve units are opened to complete a circuit for adjusting the Trendelenburg cylinder 115. In the valve bank A, valve unit "*g*" connects through a conduit 248 with conduit 139 at the rod end of the Trendelenburg cylinder. At the blank end of the cylinder, conduit 138 connects with a conduit 249 which is attached to the valve unit "*g*" in bank B. Thus, the circuit to and from the respective selector valve banks is completed for tilting the table longitudinally in Trendelenburg and reverse Trendelenburg.

Selector position "h"—Trendelenburg with leg.

In selector position "*h*" the valve units are opened to complete a circuit for adjusting the Trendelenburg cylinder 115 and the leg section cylinders 107 simultaneously. In valve bank A, valve unit "*h*" receives a conduit 230 which joins into conduit 248 thus communicating with the rod end of the Trendelenburg cylinder. Conduit 249 connecting with the conduit 138 at the blank end of the cylinder is by-passed through a conduit 251 which attaches to valve unit "*h*" in valve bank C. Through the valve unit "*h*" the circuit includes the conduits 242 and 241 which tap into the conduit 230 at junction 240, leading to the rod ends of the leg section cylinders. The circuit then includes the blank-end leg cylinder conduit 229 and a conduit 252 which branches off therefrom at junction 229′ and attaches to the valve unit "*h*" in valve bank B. The branched end of conduit 252 is also received on valve unit "*i*" which is closed. Thus a circuit is completed connecting the Trendelenburg cylinder in series with the leg section cylinders in which the circulation of actuating fluid tilts the table platform longitudinally while rotating the leg section about its hinge connection. It will be noted that in this circuit the movement of the Trendelenburg cylinders, wherein the table platform is arranged in the Trendelenburg position, is accompanied by a movement of the leg section wherein the leg section is lowered.

Selector position "i"—Chair position.

The chair position of the table is shown in Fig. 31.

In selector position "*i*" the valve units are opened to complete a circuit for adjusting the back, seat, and leg section cylinders simultaneously. In valve bank A, valve unit "*i*" is connected with conduit 253 which communicates with the compound cylinder assemblies 58 and 59, including the inner cylinders 65 and outer cylinders 66 and 67. The inner cylinders are parallel-connected with respect to each other and are placed in series with the outer cylinders which are also parallel with respect to each other, as before described. Thus the cylinders provide a compound movement which affords extended movement of the back section. The conduit 253 is connected to the blank ends of the inner cylinders 65 through the branch conduits 73 and 75. At the rod ends of the inner cylinders, branch conduits 72 and 74 join into extension conduit 243′ which communicates with the outer cylinders through the branch conduits 69 and 71, as before described. Conduit 243 is inactive since valve unit "*e*" in bank C with which it connects is not open. From the conduits 68 and 70, which join into conduit 245, the circuit continues through a juncture at 254 into a conduit 255. Line 255 is received on valve units "*i*" and "*j*" in valve bank C. Valve unit "*j*" is closed. Valve unit "*i*" being open communicates with a conduit 256 connecting at 257 with the conduit 238 of the circuit communicating with the seat section cylinders. From these cylinders conduit 239, at connection 258, taps into conduit 230 which enters into the rod ends of the leg section cylinders, as before described. At the blank ends of the cylinders the circuit continues through the conduit 229, junction 229′, and thence the branched conduit 252, to the valve unit "*i*" in valve bank B.

In the above circuit it will be seen that fluid is delivered successively to each of the pairs of cylinder devices for the back, seat, and leg sections which are connected in series. The corresponding table sections are thereby moved simultaneously.

Selector position "j"—Chair without leg.

In this position of the selector mechanism the valve units "j" are opened to actuate the compound cylinders 58 and 59 and the seat cylinders 77 and 78 simultaneously. The circuit is similar to that described above except that the leg cylinders 107 are cut out of the circuit. In valve bank A, valve unit "j" joins the common line 253 with valve unit "i" which communicates with the interconnected compound cylinder devices 58 and 59. Conduit 245 connecting with the other side of the compound cylinders returns through junction 254 and conduit 255 to the selector valve at valve unit "j" in bank C. Conduit 256 connects therewith and taps into the conduit 238 leading to the seat section cylinders 77 and 78, as before described. At the opposite fluid terminal, conduit 239 joins conduit 230 which returns to valve unit "j" in valve bank B through a connector tube 230′. The circuit is not completed through the leg cylinders since the valve unit "i" in valve bank B is closed and is not common to the conduit 230′ with the valve unit "j" which thus prevents displacement of fluid in the leg section cylinders.

OPERATION.

Having now described the arrangement of the table structure and the hydraulic control circuit therefore, the operation of the table will now be illustrated by describing the steps for adjusting the table from its normal position shown in Fig. 1 to the "chair" position seen in Fig. 31. The selector knob 154 is first rotated to adjust the index member 145 until it registers with the position "i" on the dial face 144, thereby indicating that the cam element of the selector valve is placed under the corresponding valve units "i" in valve bank A, B and C of the selector valve. This opens the designated valves and allows all the other valves to remain closed. The control handle 161 for the reversing valve mechanism is then pulled upwardly to the upper position 161′, Fig. 1, which causes the cam mechanism to be rotated in a clockwise direction. As previously stated, the first few degrees of rotation of cam bushing 186 of the reversing valve, Fig. 18, opens the line valve L allowing the high pressure of the delivery line to be impressed on the two units R_1 and R_2' of the reversing valve assembly, as shown in the circuit diagram of Fig. 21. Up to this time no flow of fluid has occurred in the system and the pump 22 has therefore remained inactive. Upon completing the rotation of adjusting handle 161 the valve units R_2' and R_1 are opened while the other units remain closed. As soon as the valves are opened the line pressure and the accumulator pressure drop causing the pressure switch 209 to energise motor 22 and start the pump 23. Oil is then picked up from the reservoir through the intake 203 and sent through conduit 204, the two line check valves 205 and 206, conduit 200′, through the main line valve L and through the valve unit R_2' to the manifold chamber 169 in the selector valve housing, Fig. 20. From this chamber pressure is impressed upon all closed valve units in the valve bank A and fluid flows through open valve "i" impressing the same pressure on the opposite side of valve unit "j." The hydraulic fluid delivered through conduit 253 and branch conduits 73 and 75 enters below the pistons of the inner back section cylinders 65, moving the pistons upward. Fluid above the pistons is discharged into conduit 243′ and passes through the branch conduits 69 and 71 into the outer back section cylinders 66 and 67 below the pistons therein. The fluid in conduit 243′ also imposes a pressure through conduit 243 against the valve unit "e" in valve bank C which is closed and therefore does not permit fluid to flow therethrough. Fluid ejected from the outer cylinders 66 and 67 as the pistons are moved upwardly therein is delivered through the conduit 245 and branch conduit 255 to the valve unit "i" in bank C. Pressure is simultaneously impressed through conduit 245 on valve unit "e" in bank B which is closed. From valve bank C the fluid proceeds through conduits 256 and 238 to the blank ends of the seat section cylinders 77 and 78. This action coincidently imposes a pressure on valve unit "e" in valve bank A which is closed. Movement of the seat section cylinder pistons causes discharge of hydraulic fluid above the pistons through the conduit 239 into conduit 230 and thence into the rod ends of the leg section cylinders. The pressure in conduit 230 is coincidently impressed upon the valve units "b" and "j" of valve bank B and valve units "e" and "h" of valve bank C which are closed. The pistons in the cylinder 107 are moved inwardly, causing fluid to be emitted therefrom into conduit 229, through junction 229′ and conduit 252 into the manifold chamber 168 through the valve unit "i" of bank B. The fluid pressure in conduit 252 is simultaneously impressed on valve unit "b" of bank A and valve unit "h" of bank B which are closed. Flow of the hydraulic fluid is then through the conduit 219, out through the reversing valve unit R_2, Fig. 21, into return line 201′, variable pressure relief valve 215, conduit 207, and thence into the reservoir 20. Thus the displacement of fluid in the control circuit produces motion of the back, seat, and leg sections while the discharge

thereof is controlled by the line pressure triggered, variable relief valve as before described. The movement of the cylinders continues until the stroke of each is completed or until the reversing valve handle is released, which closes the line valve and prevents further circulation of fluid. At the same time the increase in line pressure causes operation of pressure switch 209 which de-energises motor 22. If the valve operating handle is held in open position after completion of the table movement, the fluid line pressure will increase due to the cessation of further cylinder movement causing the pressure switch to de-energise the pump motor 22.

In order to return the table to its normal position the reversing handle is depressed into the opposite adjusting position which results in reverse displacement of fluid in the circuit and corresponding reverse cylinder movements. When each of the hydraulic cylinders has completed its movement in the return direction, the pressure switch 209 will not be actuated by further pumping of fluid because the relief valve 237' and the relief valve mechanism of the seat section cylinders are effective in conjunction with the double-acting relief valve mechanism of the leg section cylinders to permit continued circulation of fluid in the circuit as long as the handle 161 is held downwardly. By such arrangement of the relief valve devices the positions of the cylinder devices are co-ordinated after each cycle, regardless of leakages between portions of the circuit. In addition, the arrangement permits the circuit to be flushed when desired.

It will be seen that the leg section cylinders 107, which are provided with overtravel mechanisms (of the type illustrated in Fig. 11 and described in connection therewith) operable at both ends of the piston stroke wherein the fluid is vented directly through the pistons of the cylinder devices, provide in combination with other cylinder devices of similar or other types an improved hydraulic circuit. For example, the overtravel means in the leg section cylinders is effective in the circuit for the " chair position " to permit completion of the " chair position " movement in either direction although the leg section cylinders may previously have been adjusted to some intermediate position. Thus the cylinders 107 may be operated independently to drop the leg section completely. Should it be desired to later arrange the table in the chair position, it will be evident that the leg section is already in its final relative position for this movement and that fluid must be permitted to pass through the cylinders 107 until the other cylinders have been moved to their designated positions. The leg section cylinders are equipped to make this possible in either direction of movement. It will also be seen that the leg section cylinders operate in this manner in any compound circuit including two or more series-connected groups of cylinders.

The double-acting valve mechanism of the leg section cylinders and the single-acting valve mechanism of the seat section cylinders and kidney bridge cylinders are particularly desirable in the present control circuit because the overtravel fluid is flushed directly through the cylinders and not through by-pass conduits which would not enable flushing of the cylinders themselves. It will also be understood that such cylinder mechanism is also beneficial in circuits having two or more cylinder chambers of different volumes placed in series such as in the circuit just described. For example, in one embodiment of the circuit wherein the total volume displacement of the leg section cylinders may be less than the volume displacement of each of the other cylinder groups connected in series therewith it will be evident that the leg section cylinders will attain the ends of their strokes prior to the other cylinders, and that completion of the cylinder movements would be impossible except for the overtravel mechanism.

In the operation of the table mechanism for achieving the other table positions, the controls are manipulated in the same manner as above described. The selector valve is first adjusted to the desired setting, as designated on the indicator dial face. The reversing valve handle is then displaced to cause the actuating fluid to be delivered to and from the control circuit through the conduits corresponding to each of the control distribution circuits hereinbefore described.

The control of the hydraulic cylinder mechanism, whereby the rate of movement of the cylinders is maintained substantially constant independently of the load carried by the table, is provided by the constant displacement pump used in the circuit. Such a pump is adapted to deliver hydraulic fluid to the circuit at a substantially constant rate, independently of the delivery pressure, which therefore produces a uniform rate of displacement of the cylinders under all load conditions.

It is desired as an additional feature of the present control circuit to provide an adjustable speed control which may be operated to afford variable rates of table movement in which the movement will be unaffected by the table loading. This type of control, in other words, permits different speed settings of the table control circuit which will produce rates of table movement different from the rate normally occurring as a result of the fluid output of the constant displacement pump while maintaining the rate corresponding to each setting constant, regardless of the load supported by the table. The desirability for a variable speed adjustment arises from

the fact that a movement faster or slower than the one rate of movement permitted by the capacity of a constant displacement pump may be required for clinical reasons. For example, under certain circumstances it may be extremely advantageous to place the patient in a full or nearly full Trendelenburg position as quickly as possible, or it may be extremely advantageous to return the patient from a Trendelenburg position at a rate much slower than the predetermined constant displacement rate of the circuit. Another instance of the desirability of an adjustable speed control is the advantage of being able to start and stop table movement by gradual acceleration and deceleration without producing a lurch in the movement of the sections being actuated. In addition to permitting a variation of the rate of table movement it is advantageous to maintain the rate constant or independent of the load for each setting of the speed control mechanism. It may be seen, for example, that in moving a patient to or from the Trendelenburg position the load on the Trendelenburg cylinder varies over the range of its adjustment, and unless some regulating means is provided in the circuit there results a variation in the adjusted rate of movement in accordance with the changing load. Such control is accomplished in the present circuit by utilising variable circuit control means to regulate the displacement of fluid in the control circuit independently of the output of the pump. In the modified circuit a pump is used which is capable of providing a greater volume rate of delivery than that which is required for the maximum desired rate of movement of the table mechanism, as distinct from the circuit above wherein the table movement was determined by the pump output. The variable circuit control means is provided by placing a variable size orifice in series with the line valve L, downstream with respect thereto in the control circuit, and inserting a valve-controlled by-pass line between the low pressure discharge line and the high pressure delivery line which connects with the high pressure line upstream of the variable orifice. The by-pass valve is responsive to the differential pressure across the orifice to regulate the flow of by-pass fluid so that the differential orifice pressure remains constant. Thus, regardless of the table loading conditions, the rate of flow through the orifice will be entirely a function of the size of the orifice which is adjusted manually and which is varied to control the rate of table movement. A simple throttling valve is used to afford a manually-adjustable orifice.

The control circuit for the table, as shown in Figs. 20 and 21 and described in connection therewith, is modified to afford a variable speed control of this type in the manner shown in Fig. 22. In the modified circuit the outlet of line valve L of the reversing valve is connected with a conduit 200X which is connected to the throttling valve L′ in which a variable orifice is provided. The outlet of valve L′ is connected to the conduit 216 which is in turn connected with the reversing valves in banks R and R′, as previously described in connection with Fig. 21. A by-pass line 260 connects with the conduit 200X between the valve units L and L′ and passes through a by-pass speed control valve 261 into a conduit 262 which connects with the low pressure line 201′. The valve 261 is provided with a pressure tap line 263 which connects in the conduit 216 on the downstream side of the valve unit L′.

The construction of the by-pass control valve 261 is illustrated in Fig. 27. Referring to this figure, the valve comprises a valve body 265 having a valve inlet 266 to which the inlet line 260 is connected and an outlet 267 which connects with the conduit 262. A cylindrical bore 268 is disposed substantially centrally within the valve body extending from the inlet 266 to a rear pressure chamber 269. At a longitudinally-spaced point within the bore 268 an annular recess 270 is formed, at the bottom of which radial openings 271 connect with an outer annular recess 272 that registers with the valve outlet 267. A valve element 273 is slidably disposed in the bore 268 and is lodged against a shoulder abutment 274 in the pressure chamber 269 by means of a spring 275 compressed thereagainst by an end plug 276. The element 273 is adapted to move longitudinally within the valve body 268 to regulate the passage of fluid from the inlet 266 to the outlet 267. Fluid from the downstream side of the variable orifice is admitted through the tap line 263 and a fitting 277 on the valve housing through an opening 278 into the pressure chamber 269. The fluid pressure therein acts against the end of the valve element 273 in the opposite direction to that of the pressure of fluid from the upstream side of the variable orifice in the valve inlet 266 which acts against the other end of the valve element. When the valve is in operation the valve element 273 is displaced to regulate the flow of by-pass fluid between the valve inlet and outlet ports so that the differential pressure, resulting from the pressures acting against opposite ends of the valve element, is maintained so as to produce a force on the valve element substantially equal to the force of the valve spring 275. Thus it will be seen that the force of the valve spring represents the equivalent of the differential pressure across the variable orifice, as reflected in the inlet 260 and the pressure chamber 269, which is always maintained constant.

The line valve L′, constituting the variable

orifice, is contained in the reversing valve assembly 147. Thus in the preferred arrangement the construction of the reversing valve assembly 147, shown in Fig. 18, is modified slightly to accommodate the valve unit L′ in the manner shown by the modified construction of Fig. 24. The valve unit L′ is substantially the same as the other valve units of the master valve except that its valve-engaging surface with the valve seat is preferably tapered in a manner well understood in the art to afford an increased flow throttling range of adjustment. As seen in the cross-sectional view of Fig. 25, the reversing valve cam bushing member 186 is provided with the recess portion 189′ that is in radial registry with the protruding end of the element of the valve unit L′. The recess 189′ comprises a depressed, curved cam surface which is correlated with the depression 189 such that the valve L′ opens subsequent to the valve unit L upon rotation of the operating shaft 148.

In addition, the cam surface 189′ is related to the flat surfaces 188 and 187, Figs. 18 and and 23, so that the valve unit L′ is opened substantially at the same time as the corresponding valve units in valve banks R and R′. By suitably dimensioning the curvature of the surface 189′ so that it tapers off gradually, the valve unit L′ is caused to open slightly when the cam bushing is in a position to fully open the other valve units, and to gradually open further as rotation of the operating shaft 148 is continued.

Thus it will be seen that the manipulation of the valve operating handle 161, in the modified valve control mechanism and control circuit, causes not only the opening of the line valve and directional control of the fluid displacement in the control circuit but also regulates the opening of the variable orifice of valve unit L′ and consequently the rate of movement of the hydraulic table actuating mechanism.

The present invention affords an improved hydraulic surgical table which is of unique construction especially adapted to accommodate complete hydraulic motivation and which is provided with an improved hydraulic actuating and control circuit having reliable and readily accessible hydraulic controls. It is to be understood that the invention is not limited to the specific embodiments herein illustrated and described but may be used in other ways without departure from its scope as defined by the following claims.

What we claim is:—

1. An hydraulic surgical table having a base and a vertically-adjustable pedestal, a frame, mounting means for supporting said frame on said pedestal, and is plurality of adjustable table platform sections mounted on adjustable hydraulic cylinder devices carried by said frame, and means for actuating said cylinder devices to change the position of said table platform sections relative to said frame.

2. An hydraulic surgical table according to Claim 1, characterised by the fact that it includes adjustable hydraulic devices associated with said frame mounting means for changing the position of said frame relative to said pedestal.

3. An hydraulic surgical table according to Claim 1, characterised by the fact that said mounting means includes a yoke or like fitment rotatable about horizontal pivot means on said pedestal and further characterised by the fact that it includes a hydraulic cylinder device operatively connected with said fitment for rotating the same about said pivot means, hinge means connecting said frame and said fitment providing for rotation of said frame about an axis transverse to the horizontal axis of rotation of said fitment about said pivot means, and a second hydraulic cylinder device operatively connected with said frame for rotating the same about said transverse axis.

4. An hydraulic surgical table according to Claim 3, characterised by the fact that it includes at least one hydraulic cylinder device operatively connected with each of said table platform sections, and an hydraulic control circuit for selectively actuating said hydraulic cylinder devices.

5. An hydraulic surgical table according to Claim 1, wherein the adjustable table platform sections are mounted for movement relative to each other and comprise a back section, a seat section, an intermediate section and a leg section said intermediate section being located between said back section and said seat section, and characterised by the fact that it includes a first hydraulic cylinder device operatively connected to said intermediate section for adjusting it vertically with respect to said frame, a second hydraulic cylinder device pivotally mounted on said frame and operatively connected to said back section, a third hydraulic cylinder device pivotally mounted on said frame and operatively connected to said seat section, said second and third cylinder devices being adapted to adjust said back and seat sections angularly with respect to each other, a fourth hydraulic cylinder device hingedly mounted on said seat section operatively connected with said leg section for rotating it with respect to said seat section, and an hydraulic control circuit for selectively actuating said hydraulic cylinder devices.

6. An hydraulic surgical table according to Claim 4, characterised by the fact that said frame is rigid and supports said hydraulic cylinder devices for said platform sections and said platform sections and further characterised by the fact that it includes

means operatively connected with the pedestal and said first hydraulic cylinder device.

7. An hydraulic surgical table according to Claim 1, characterised by the fact that it includes a yoke or like fitment supporting said frame on said pedestal, said fixture being rotatably mounted on said pedestal on a horizontal axis and containing a first double-acting hydraulic cylinder device disposed on an axis transverse to said horizontal axis, said first cylinder device comprising a cylinder barrel and a piston relatively movable therein, means for rotatably mounting said frame on said cylinder barrel, a piston rod connected to said piston and means connecting said piston rod and said pedestal for maintaining said piston fixed relative to said pedestal in all angular positions of said fitment so that fluid actuation of said first hydraulic cylinder device causes movement of said cylinder barrel relative to said piston and rotation of said fitment and said frame about said horizontal axis, and a second double-acting hydraulic cylinder device disposed substantially at right angles to said first cylinder device operatively connected with said frame and said fitment for rotating said frame about the axis of said first cylinder device.

8. An hydraulic surgical table according to Claim 7, characterised by the fact that it includes an arcuate gear segment rigidly mounted on said pedestal in a vertical plane parallel to the longitudinal axis of said first cylinder device, a transverse member received on the outer end of said piston rod, a rack bar connected thereto and extending substantially parallel to said piston rod, said rack bar having teeth thereon meshing with the teeth on said gear segment, said gear segment and said rack bar being constructed and arranged so that said teeth remain in mesh in all rotated positions of said fitment member, laterally spaced arm extensions on said fitment between which said double acting cylinder is mounted, and fluid ports in the first and second cylinder devices for admitting and discharging actuating fluid to and from said cylinder devices to selectively produce rotation of said fitment about said horizontal axis and said table frame about the axis of said first cylinder device.

9. An hydraulic surgical table according to Claim 1, wherein each hydraulic cylinder device comprises a cylinder and a piston therein and the actuating means for said cylinder device comprises a plurality of fluid lines connected in pairs with each of said cylinders on opposite sides of said piston, a separate valve unit in each of said fluid lines, the two valve units associated with each pair of fluid lines connecting with the same cylinder constituting a corresponding pair of valves, one valve unit of each of said corresponding pairs being arranged in a first valve group having a first manifold chamber common to all of the valves in said first group and the other valve unit of each of said corresponding pairs being arranged in a second valve group having a second manifold chamber common to all of the valves in said second group, selector means for selectively operating said corresponding pairs of valves to provide circuits connecting selected ones of said fluid motor means with said first and second manifold chambers, a pair of manifold fluid lines communicating with said first and second manifold chambers and connecting with a reversing valve housing, high and low pressure fluid supply and discharge conduits connecting with said reversing valve housing, valve means in said reversing valve housing for alternatively connecting said high pressure supply line with either of said manifold lines and for simultaneously connecting said low pressure discharge line with the other of said manifold lines, a fluid pump having a high pressure outlet connected with said high pressure supply line, said pump having an inlet connecting with a fluid reservoir, and means connecting said low pressure discharge line with said reservoir whereby fluid may be pumped through said control circuit for actuation of said fluid motor means.

10. An hydraulic surgical table according to Claim 9, characterised by the fact that the pump is a constant displacement pump.

11. An hydraulic surgical table according to Claim 9, characterised by the fact that it includes flow-restricting means in said low pressure discharge line for limiting the rate of flow of discharge fluid to a predetermined maximum.

12. An hydraulic surgical table according to Claim 11, characterised by the fact that it includes means associated with said high pressure line for enabling the pressure of the fluid therein to vary the flow capacity of said restricting means as a function of the increase of said pressure.

13. An hydraulic surgical table according to Claim 1 or 2, characterised by the fact that the actuating means for the cylinder devices comprises a source of high pressure fluid, a reservoir for fluid under relatively low pressure, high and low pressure fluid lines respectively connecting said source and said reservoir with said cylinder devices, a variable orifice in said high pressure line, by-pass line between said high pressure line and said low pressure line connected upstream of said orifice, and a regulating valve in said by-pass line responsive to the differential pressure across said orifice to regulate the flow of by-pass fluid and maintain said differential orifice pressure constant.

14. An hydraulic surgical table according to Claim 1 or 2, characterised by the fact that

the hydraulic cylinder devices are double acting and the actuating means for the cylinder devices comprises a pair of fluid distributing lines connected with each of said cylinder devices, means connecting said distributing lines in series with high and low pressure main lines for respectively supplying and discharging fluid to and from each of said cylinder devices, said connecting means including reversing valve means for alternatively connecting said high and low pressure main lines with each pair of said fluid distributing lines in either of two reversed flow positions for producing forward or reverse movement of each of said cylinder devices, adjustable flow restriction means in said low pressure main line for restricting the discharge of fluid therethrough, and means responsive to the pressure of the fluid in said high pressure main line for adjusting said flow restriction means.

15. An hydraulic surgical table according to Claim 14, characterised by the fact that said high pressure main line is supplied with high pressure fluid by a constant displacement pump.

16. An hydraulic surgical table according to Claim 14, characterised by the fact that said flow restriction means in the low pressure main line is spring mounted and limits the volume rate of discharge therethrough when the applied load on said cylinder devices is co-directional with the direction of fluid displacement therein.

17. An hydraulic surgical table according to Claim 1 or 14, characterised by the fact that each of the hydraulic cylinder devices includes a double acting piston reciprocally movable within a cylinder barrel and further characterised by the fact that it includes a source of fluid under relatively high pressure, a low pressure storage reservoir, high and low pressure fluid lines connecting with said source and said reservoir respectively, distributing fluid lines connecting with each of said cylinder devices comprising pairs of conduits connected on opposite sides of said pistons in said cylinder barrels, valve means selectively operable to connect said cylinder devices separately through corresponding ones of said distributing lines with said high and low pressure lines or to connect two or more of said devices in series with each other and with said distributing lines, and valve means contained in the piston of at least one of said cylinder devices mechanically operable at least at one end of the piston stroke to permit passage of fluid therethrough, said valve means being effective to maintain a differential pressure across said piston sufficient to support the load applied to the cylinder device.

18. An hydraulic surgical table according to Claim 2, characterised by the fact that each of said hydraulic cylinder devices comprises a cylinder having a double acting piston therein and further characterised by the fact that it includes a master valve assembly mounted on said frame, separate fluid lines connecting said master valve with each of said hydraulic cylinder devices on opposite sides of the pistons therein forming individual distribution circuits between the master valve and each of said hydraulic cylinder devices, valve means contained in said master valve for opening and closing each of said fluid lines in said individual circuits, a source of fluid under pressure contained in said table base, a depository for low pressure fluid in said base, extensible high and low pressure fluid lines extending from said source and said depository through said adjustable pedestal and connected with said master valve, and control means operatively associated with said master valve for actuating said valve means contained therein to selectively open and close said separate lines.

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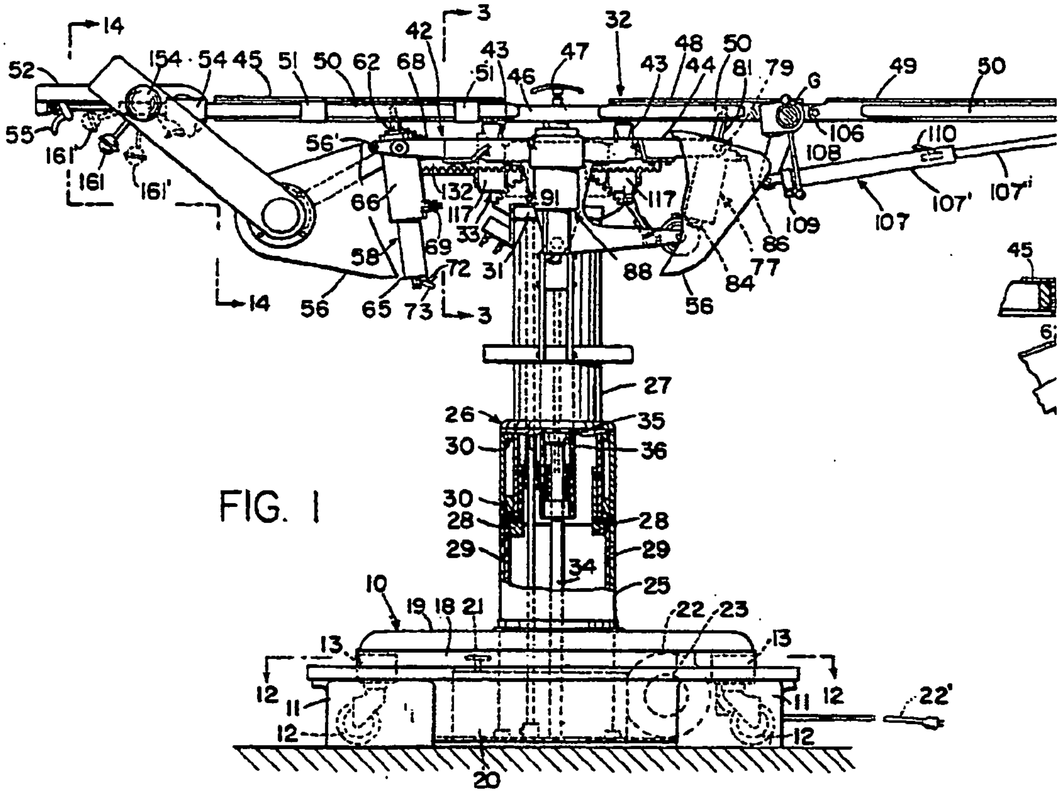

FIG. 1

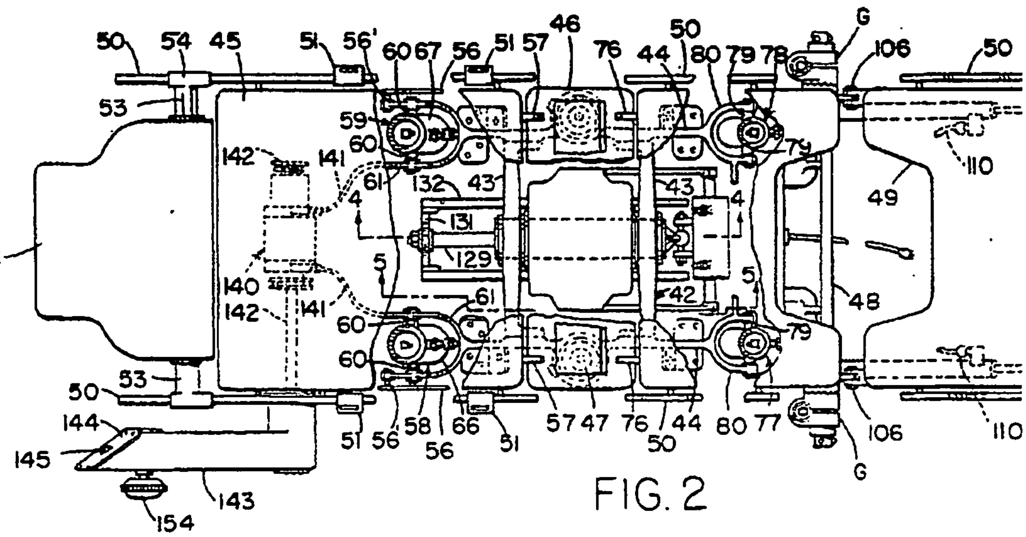

FIG. 2

728,093 COMPLETE SPECIFICATION
5 SHEETS
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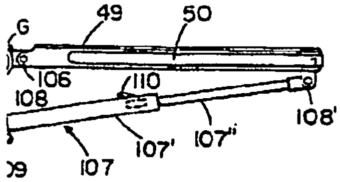
SHEET 1



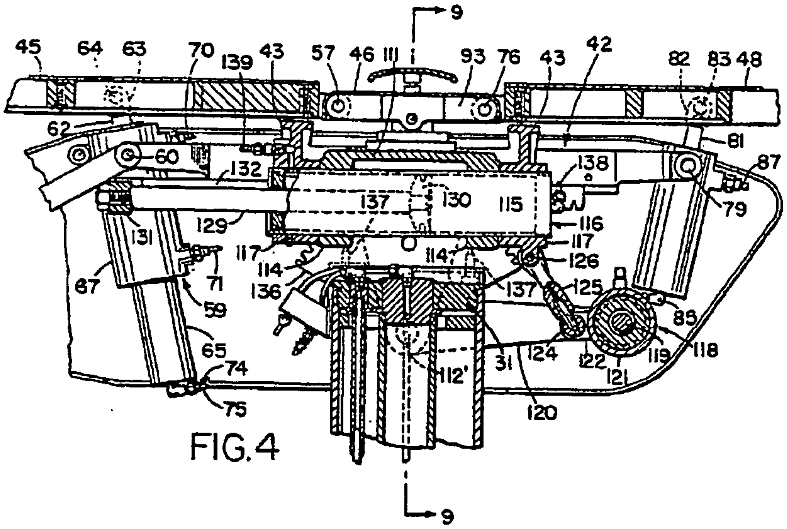
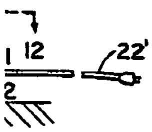
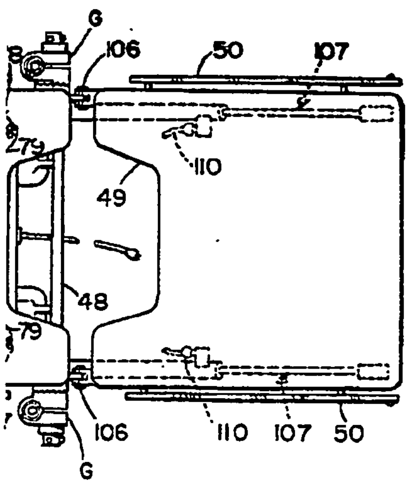


FIG.4





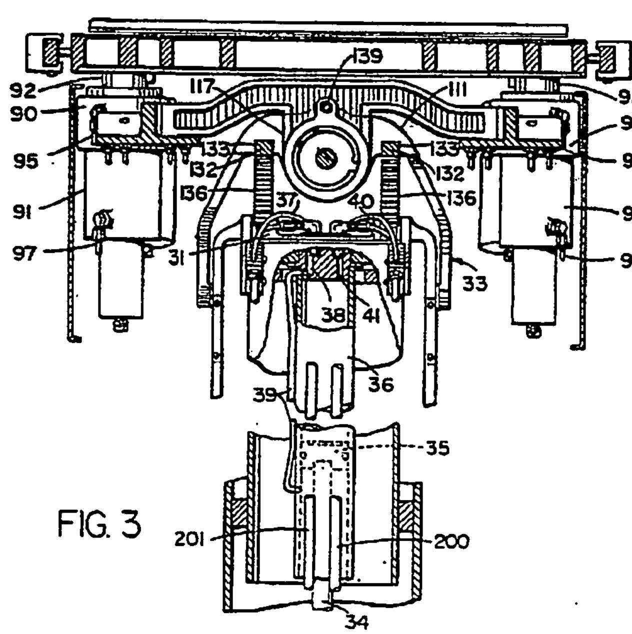


FIG. 3

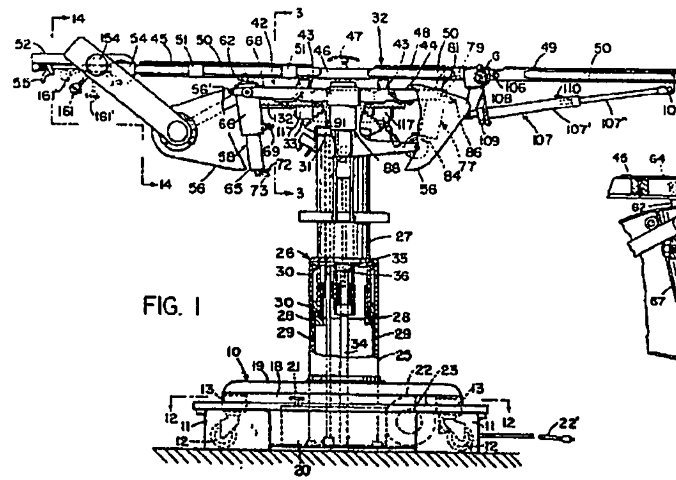


FIG. 1

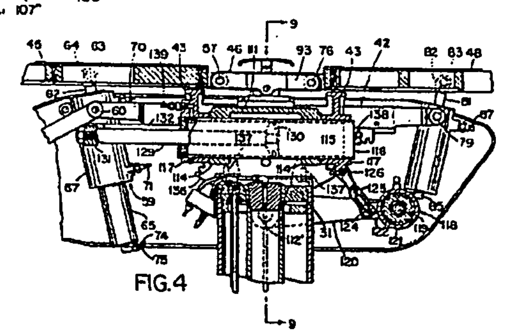


FIG. 4

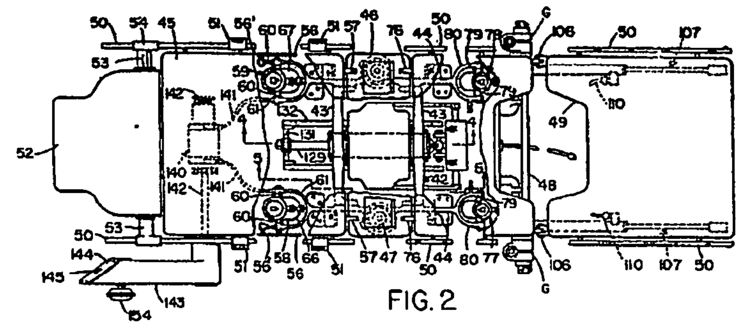


FIG. 2

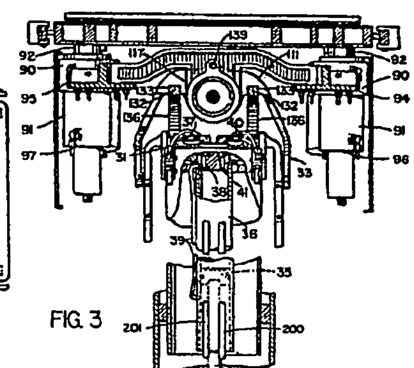


FIG. 3

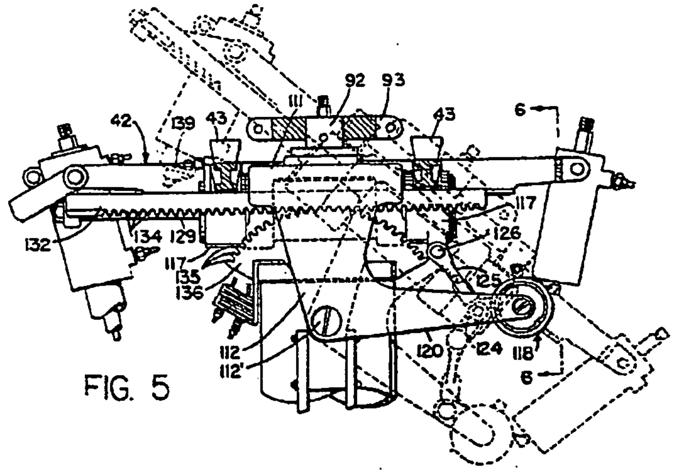


FIG. 5

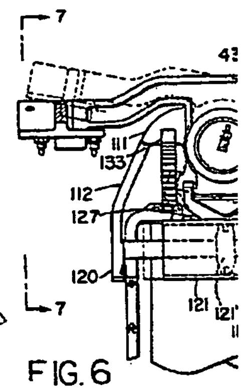


FIG. 6

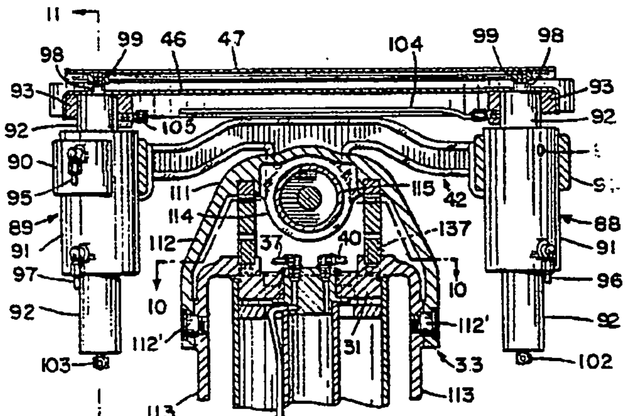


FIG. 9

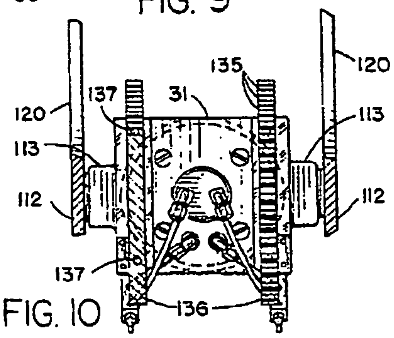


FIG. 10

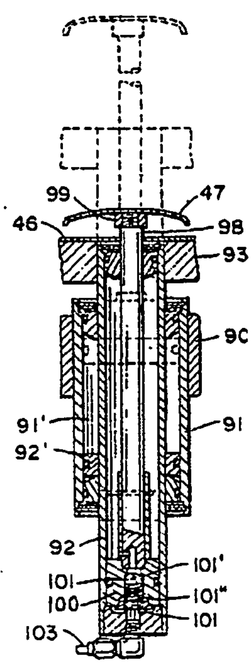


FIG. 11

728,093 COMPLETE SPECIFICATION
5 SHEETS

This drawing is a reproduction of the Original on a reduced scale.
SHEET 2

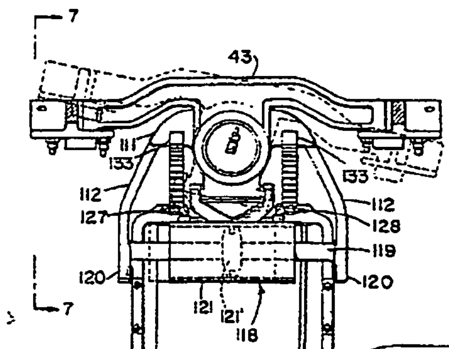


FIG. 6

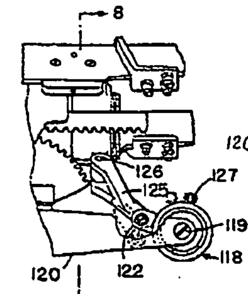


FIG. 7

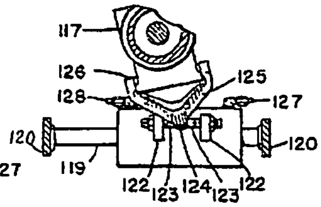


FIG. 8

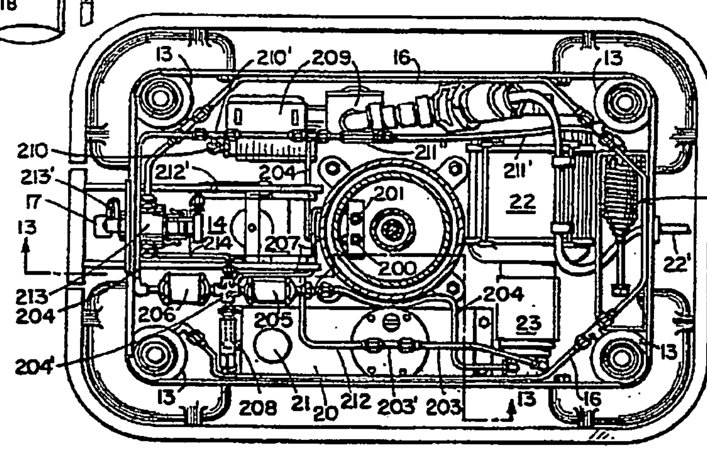


FIG. 12

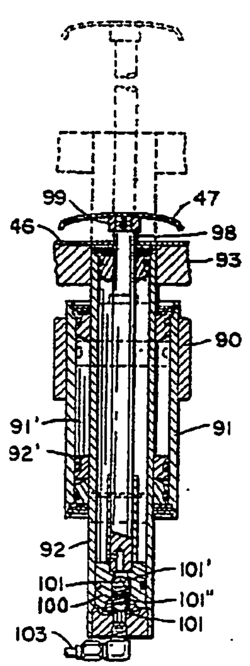


FIG. 11

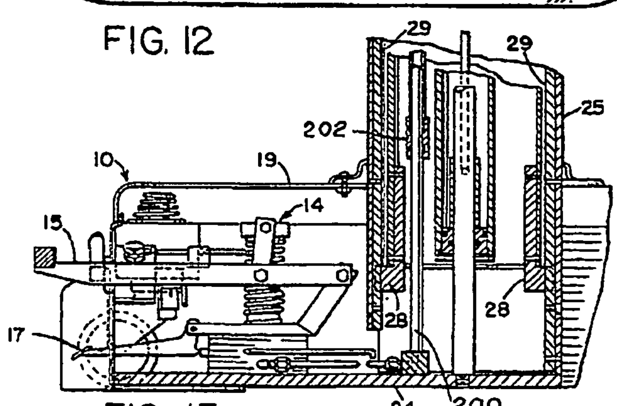


FIG. 13

728 093 COMPLETE SPECIFICATION
5 SHEETS This drawing is a reproduction of the Original on a reduced scale.
SHEET 2

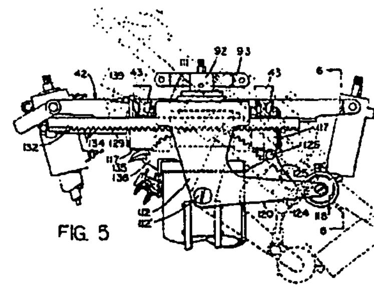


FIG. 5

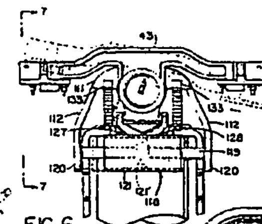


FIG. 6

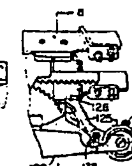


FIG. 7

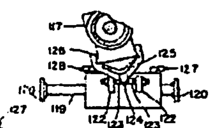


FIG. 8

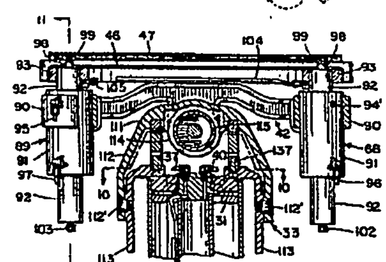


FIG. 9

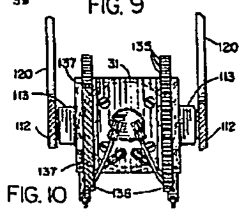


FIG. 10

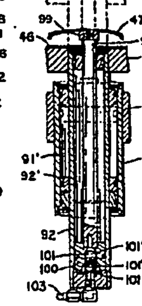


FIG. 11

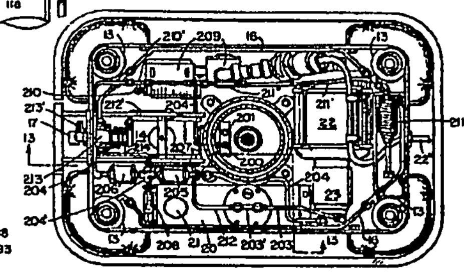


FIG. 12

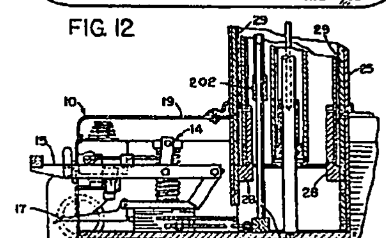
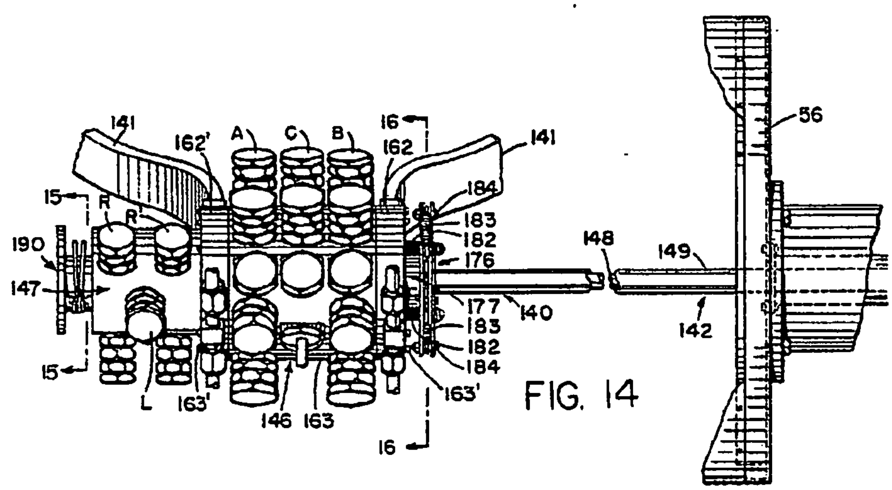
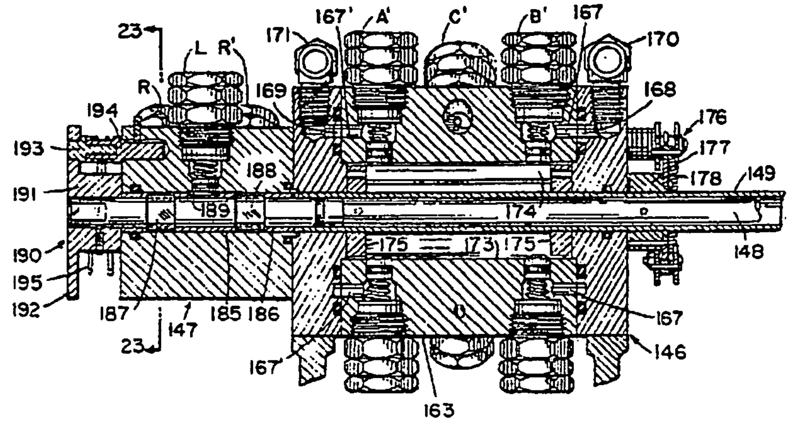
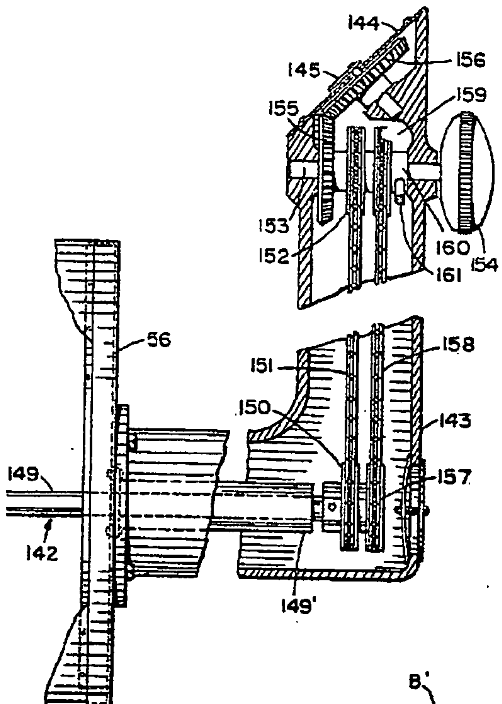


FIG. 13


141
162'
A
C
B
16
162
141
56
15
R
R'
184
183
182
190
176
148
149
147
177
140
183
142
182
184
15
L
163'
146
163
163'
16
FIG. 14


23
171
167'
A'
C'
B'
167
170
L
R'
R
194
169
168
176
193
188
177
178
149
191
189
174
148
175
173
175
190
195
192
187
147
185
186
167
23
167'
146
163
FIG. 18

728.093 COMPLETE SPECIFICATION
5 SHEETS
This drawing is a reproduction of the Original on a reduced scale.
SHEET 3



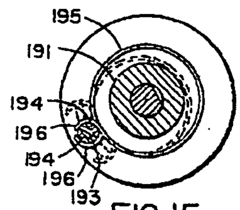


FIG. 15

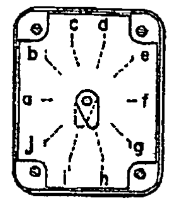


FIG. 17

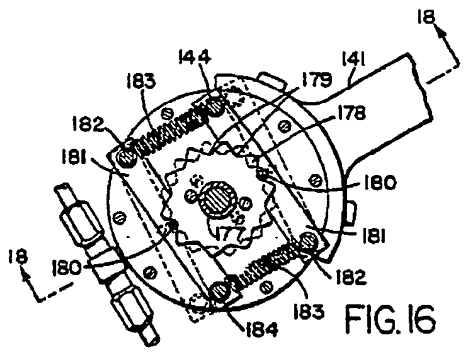
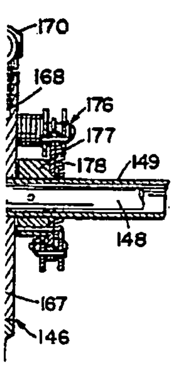


FIG. 16



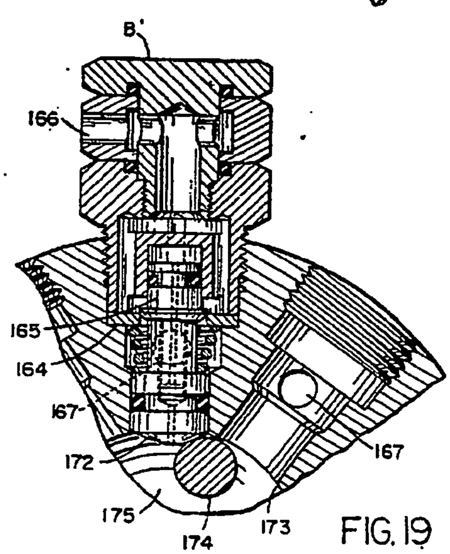


FIG. 19

728,093 COMPLETE SPECIFICATION
5 SHEETS
This drawing is a reproduction of the Original on a reduced scale.
SHEET 3

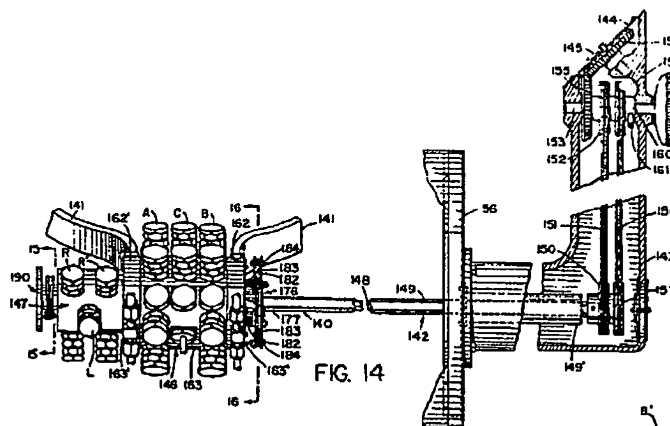


FIG. 14

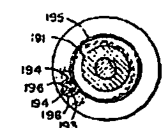


FIG. 15

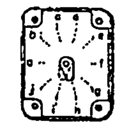


FIG. 17

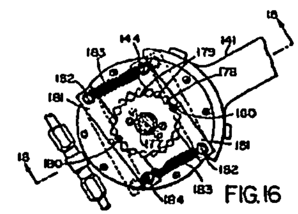


FIG. 16

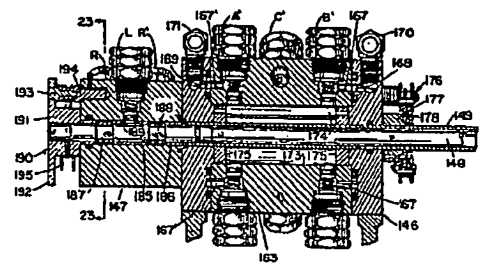


FIG. 18

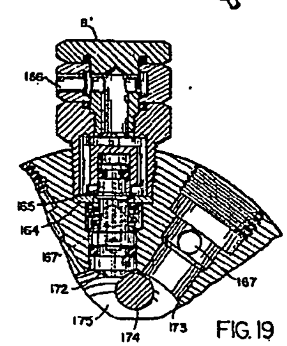
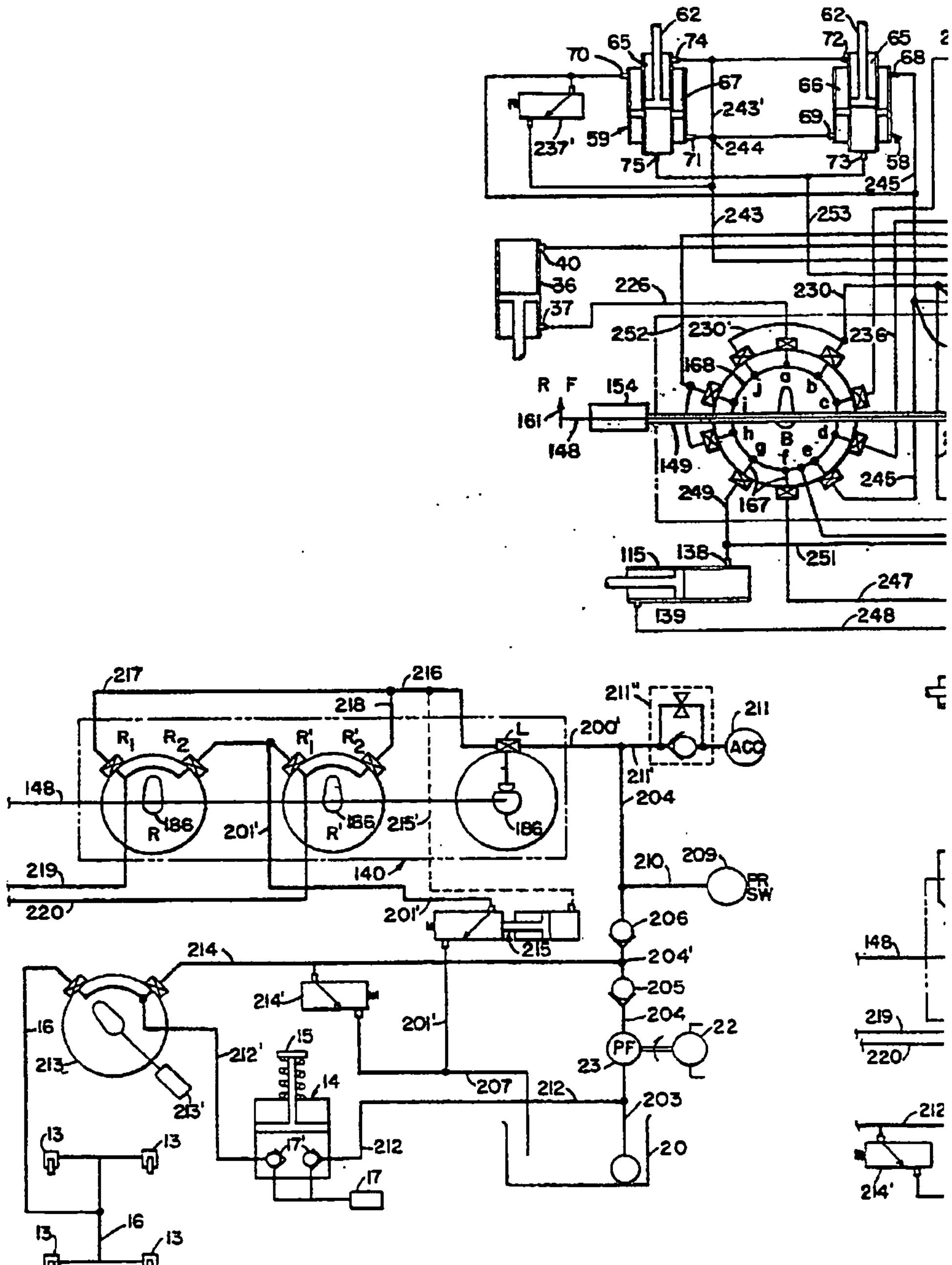


FIG. 19


R F
ACC
PR SW
PF
L
FIG. 21

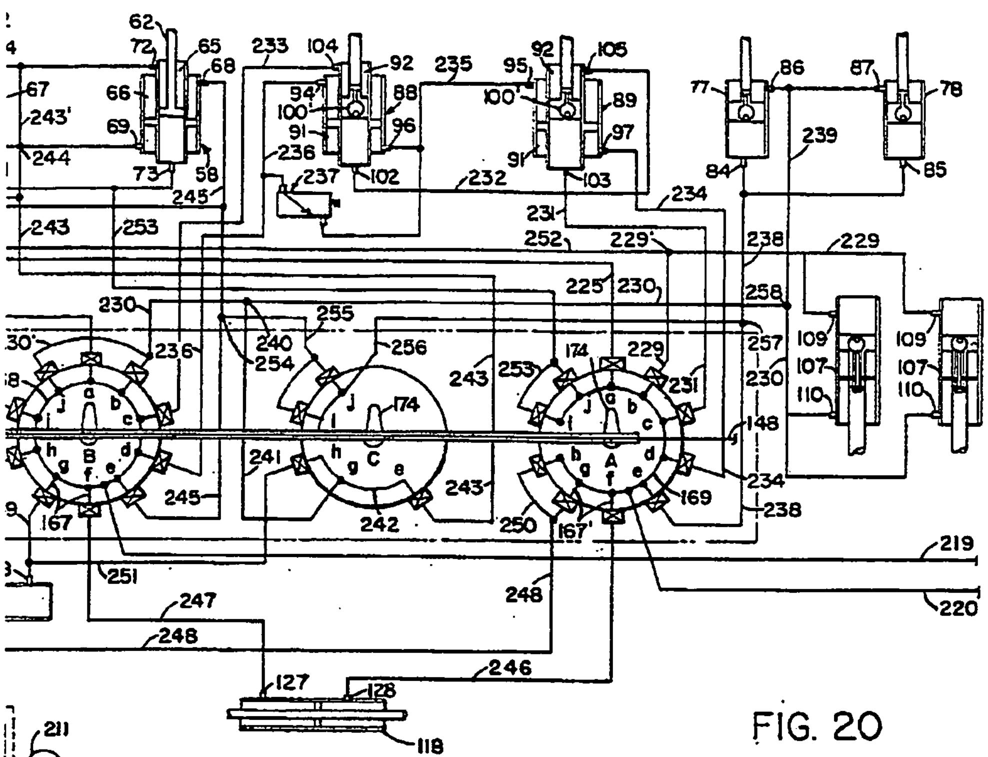


FIG. 20

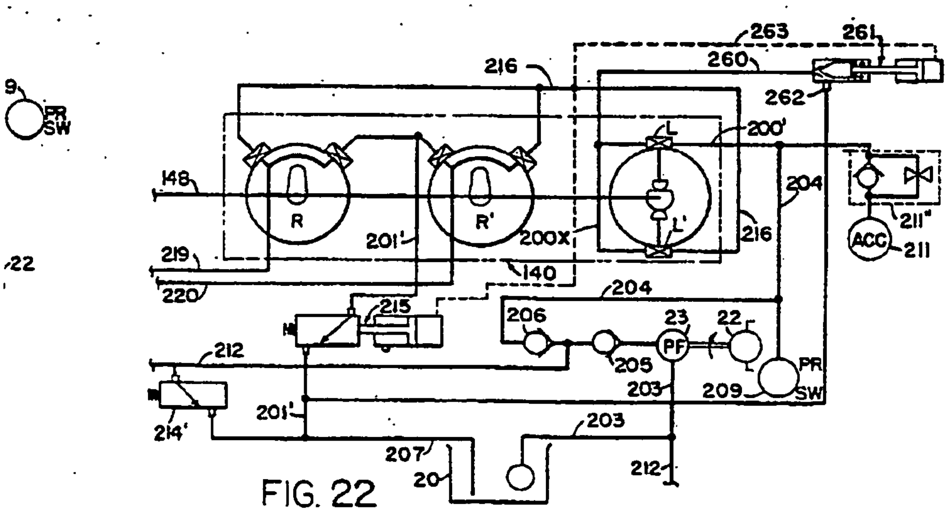


FIG. 22

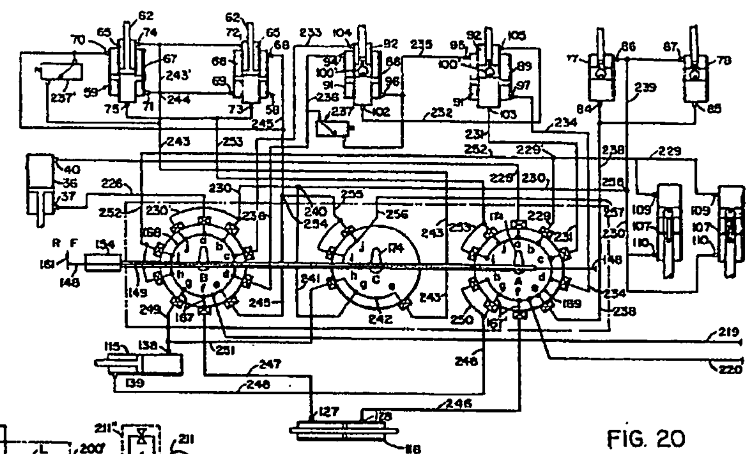


FIG. 20

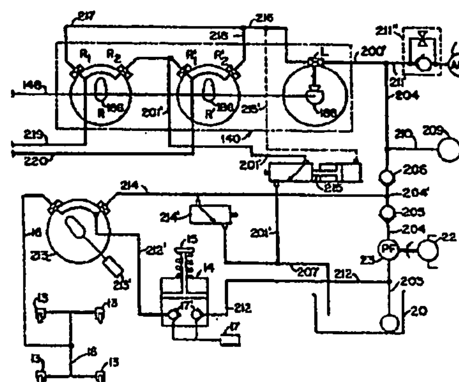


FIG. 21

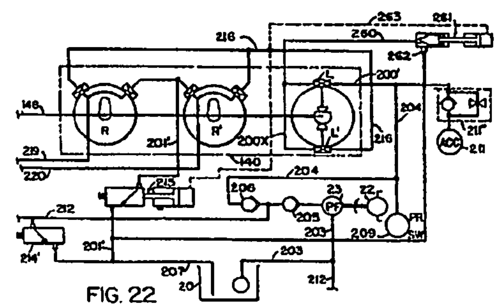


FIG. 22

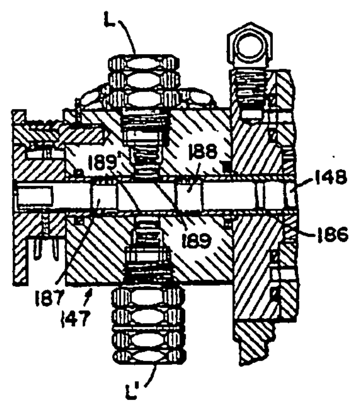


FIG. 24

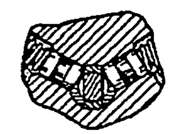


FIG. 23

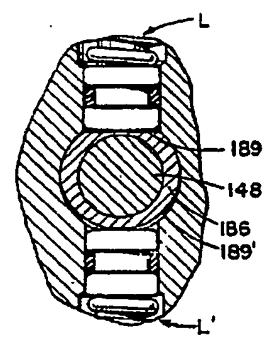


FIG. 25

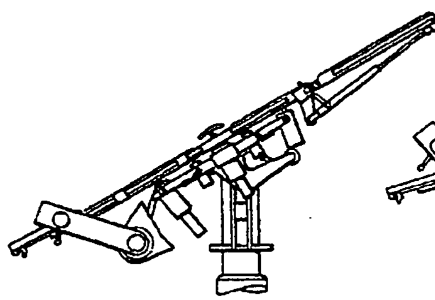


FIG. 28

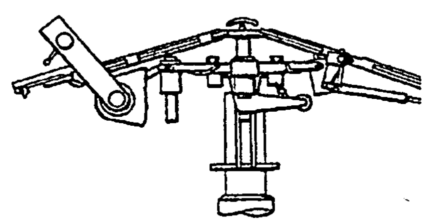


FIG. 29

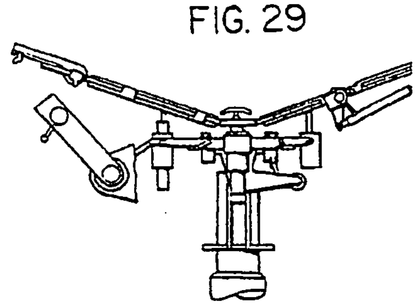


FIG. 30

728,093 COMPLETE SPECIFICATION
5 SHEETS
This drawing is a reproduction of the Original on a reduced scale.
SHEET 5

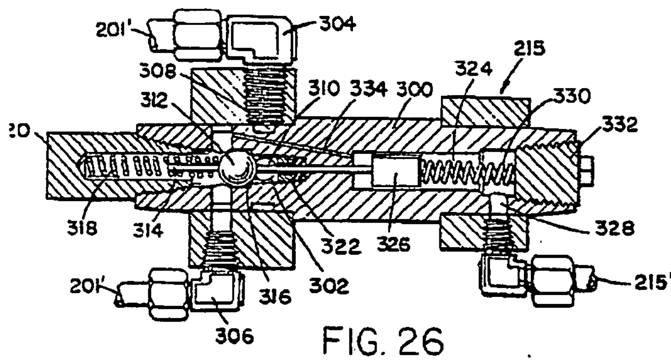


FIG. 26

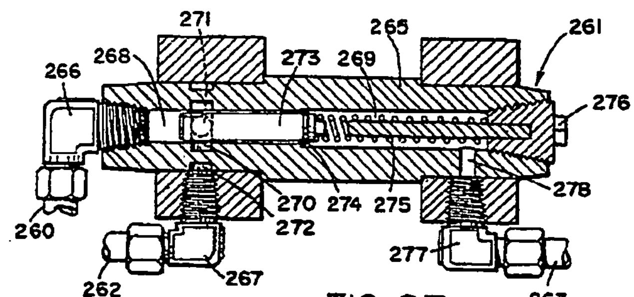


FIG. 27

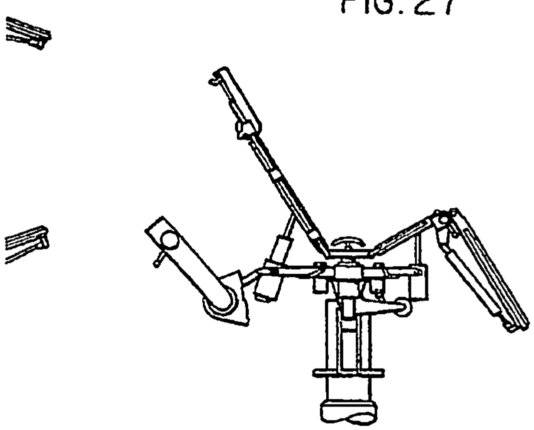


FIG. 31

728,093 COMPLETE SPECIFICATION
5 SHEETS
This drawing is a reproduction of the Original on a reduced scale.
SHEET 5

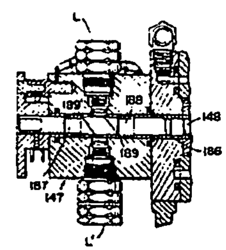


FIG. 24

FIG. 23

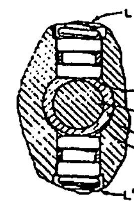


FIG. 25

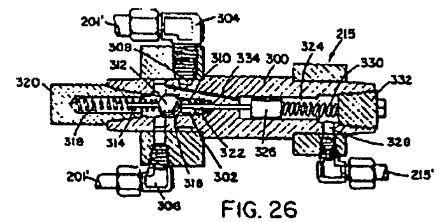


FIG. 26

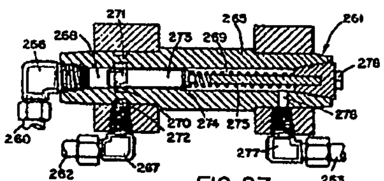


FIG. 27

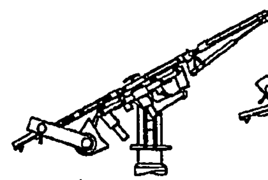


FIG. 28

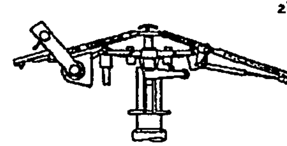


FIG. 29

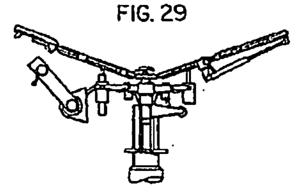


FIG. 30

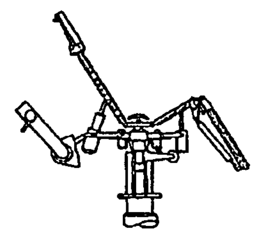


FIG. 31